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The Federal Aviation Administration Plan for Research, Engineering, and Development

Volume II: Project Descriptions

January 1989

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Cover Photograph: Terminal Doppler Weather Radar

Terminal Doppler weather radar (TDWR) is designed to detect windshear and other hazardous weather phenomena and to automatically warn pilots and controllers of such conditions. A major goal of the TDWR program (Project 7.2) is the detection of microbursts, the most hazardous form of windshear, for aircraft approaching or departing from airports.

Pictured here are a "dry" microburst detected by TDWR and two radar screen displays showing its reflectivity and velocity. The radar reflectivity factor (z), which is related to precipitation, shows a level within the red bounding box of about 10 to 15 dB. Since approximately 30 dB represents measurable precipitation, the microburst has been classified as dry. The windshear velocity display indicates positive values, in the range from 7.8 to 10.4 meters per second, in the upper part of the bounding box and negative values in the lower part of the box. These positive and negative velocities indicate that the microburst is spreading as it gets closer to the ground.

Data were recorded on June 12, 1987, by the FAA's FL-2 TDWR testbed at the Denver Stapleton Airport. The radar elevation angle was 0.5°.

U.S. Department
of Transportation

**Federal Aviation
Administration**

The Federal Aviation Administration Plan for Research, Engineering, and Development

Volume II: Project Descriptions

January 1989

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1. Guide to Project Plans

The Federal Aviation Administration (FAA) Research, Engineering, and Development (RE&D) Plan addresses the present and future needs of the national aviation system through fulfillment of the FAA's major mission areas. The purpose, scope, and primary objectives of the plan are presented in Chapters 1 through 4 of Volume I. This volume contains detailed descriptions of the projects included in the RE&D Plan. For planning purposes, the time frame is broken into three "windows," with 1989 to 1995 composing the near term, 1996 to 2005 the mid-term, and 2006 to 2015 the far term.

The project plans described in this volume have been organized into the following 13 technical areas: system studies, air traffic control, communications, navigation and landing, surveillance, aviation weather, satellite applications, airborne systems, airports, aircraft safety, aviation medicine, security, and human systems and operations.

Numerical and alphabetical indexes of all the projects in this plan are presented in Appendix A. Appendix B is a glossary of acronyms and abbreviations.

Each RE&D project described in this volume is assigned a project reference number and is presented in the following format:

Responsible Division

The division within the FAA responsible for the day-to-day management of the project.

Purpose

The overall goal to be achieved by the project.

Approach

An overview of the principal project activities, to include scope and technical approach.

Products

The major tangible products expected from the project, such as reports, prototype equipment, and specifications.

Recent Accomplishments

A list of key project activities that have been completed to date.

Related Projects/Activities

A list of projects that involve activities prerequisite to or interdependent with the project being described, including a brief description.

Schedule

A presentation of major project activities and milestones on a time line by calendar year. As illustrated in Figure 1-1, project activities are divided into three major groups. The RE&D activities include those that are the principal research and development efforts. The second group includes standards, guidelines, and procedures related to the project activities. The facilities and equipment (F&E) group covers procurement activities related to the RE&D project. F&E activities included in the FAA's current National Airspace System (NAS) F&E Plan are represented by circles on the schedules. In addition, hypothetical new F&E procurements are shown to illustrate the time frames within which implementation can be expected, provided the RE&D activity is successful and a decision is made to implement the feature developed. These hypothetical new F&E procurements are represented by triangles on the schedules. F&E activities are not funded by the RE&D appropriations. It should be noted that not every project in this plan will include all three groups of activities.

Project X.X

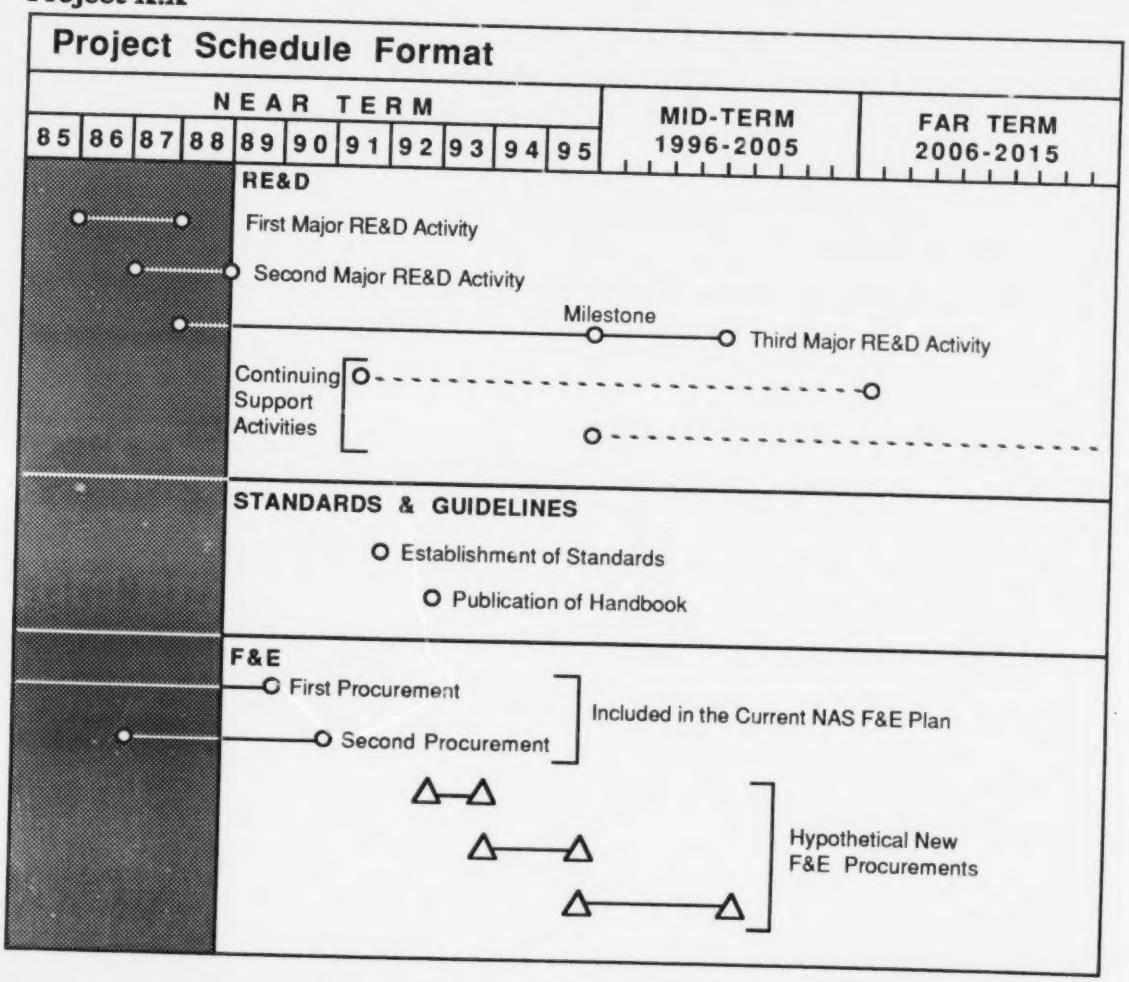


FIGURE 1-1 -- PROJECT SCHEDULE FORMAT

2. System Studies

There are 13 planning or study projects which address the national aviation system either as a whole or as multiple technical areas. These projects are grouped into four areas: management and control, advanced concept studies, dynamic airspace and airport system models, and cooperative research. Such projects are primary supports to the FAA's efficiency mission. The projects are as follows:

Management and Control	
2.1	NAS System Requirements
2.2	Research, Engineering, and Development Plan
2.3	Management and Control Process
2.4	System Engineering Management
2.5	ADM Program Support/Management Initiatives
Advanced Concept Studies	
2.6	Future System Definition
Dynamic Airspace and Airport System Models	
2.7	Simulation Model Development and Validation (SIMMOD)
2.8	National Airspace System Performance Analysis Capability (NASPAC)
2.9	Airspace System Models
Cooperative Research	
2.10	Joint University Air Transportation Technology Program
2.11	Transportation Research Board
2.12	Small Business Innovation Research Program
2.13	FAA/NASA Cooperative Programs

As now reflected in Project 2.2, the FAA is committed to a new direction for its RE&D program and for the manner in which the agency prioritizes and allocates its RE&D resources. The goal of the revitalized program is to better provide the FAA and the aviation community with the means for meeting future challenges. As part of the revitalized RE&D activity, the FAA has taken steps to strengthen partnerships with other government agencies, industry, and academia. The new program will emphasize a careful balance between support for the National Airspace System (NAS) Facilities and Equipment (F&E) Plan and that for the FAA's safety, security, and technical-assistance responsibilities. RE&D emphasis has shifted from support of the initial NAS F&E Plan to plan enhancements and current FAA needs. These efforts will be balanced with long-term research geared toward setting a framework for the aviation demands of the 21st century.

A critical feature of the new RE&D Plan is the introduction of a top-down, goal-oriented planning process. Future resource allocation will emphasize those programs which have the greatest potential for achieving agency goals. A concept of goal-oriented major mission areas is being developed to help analyze the programs required to meet these objectives. Four mission areas -- capacity, safety, security, and efficiency -- have been selected that encompass the FAA's operational, regulatory, technical-assistance, and policy-making responsibilities. Goals will be assigned to each mission area, and RE&D projects will be analyzed as to how well they support these objectives.

To provide direction for the new RE&D program, the FAA has recently established the position of Associate Administrator for Advanced Design and Management Control (ADM). The associate administrator has responsibility for providing a greater emphasis on several technical and managerial areas, including: management and control of the operational requirements of the NAS F&E Plan; preparation, management, and control of the annual FAA RE&D Plan; development of a long-term operations research and analysis capability; and cooperative research programs with other government agencies, academia, and industry.

A continuing evaluation will be made of the projected performance of the NAS F&E Plan in light of future demand, evolving requirements, and available technology. Concept analysis will be performed to gain an understanding of the future aviation environment, and areas requiring RE&D will be identified.

As a complement to studies on needed NAS F&E Plan improvements, the FAA will examine concepts and technologies for improving the future aviation system. Such efforts will lead to the definition of the specific RE&D projects that will best meet projected user and industry requirements. The focus of this activity will be on the post-2010 time frame, when increasing demand for air services and anticipated improvements in information storage, processing, and communications technologies may necessitate a significant restructuring of the national aviation system.

Critical tasks for the new associate administrator will be to develop and publish an annual RE&D Plan and to establish a process by which the FAA will monitor and control the RE&D budget. Goals will include the provision of a basis for more informed decisions by FAA management and the formation of a budget that best meets the needs of the total aviation community. The FAA is currently developing a process for the review and oversight of the RE&D program. This process will involve a series of symposia, workshops, and conferences held to obtain the views of the aviation community. An RE&D management information system will be implemented to ensure that top-level FAA managers have the best information available to support annual RE&D budget decisions.

In response to recommendations from the President's Aviation Safety Commission, the Office of Technology Assessment, and the aviation community, the FAA is enhancing its internal operations research and modeling capabilities. Major effort is being placed on Simulation Model Development and Validation (SIMMOD), for airspace and airport simulation, and on the National Airspace System Performance Analysis Capability (NASPAC), for assessment of the nation's airspace utilization on a systemwide basis.

An essential element of the RE&D program is the access to and use of all available technical resources within government and the academic and aviation communities.

The Joint University Air Transportation Technology Program sponsors multidisciplinary research relative to the future aviation system and develops the students necessary for system management. These projects address a wide spectrum of disciplines, and ranging from the evaluation of cockpit displays of critical weather information to analyses of the decline of U.S. leadership in the general aviation industry.

Work is proceeding with the Transportation Research Board on stimulating academic research in areas concerning technical and management innovations for civil aviation in the 21st century. This objective is being accomplished through grants and through workshops on the future of aviation.

The FAA works closely with the National Aeronautics and Space Administration (NASA) in several ways, including the contribution of funding to NASA's in-house research programs, joint NASA/FAA research, and research at NASA facilities conducted by FAA personnel. To carry out these activities, FAA field offices have been established at NASA's Ames and Langley Research Centers. Programs presently under way or soon to be initiated address such issues as rotorcraft instrument flight capability, airborne windshear detection and avoidance studies, cockpit display technology, storm hazards research, noise-abatement technology, and air traffic systems automation. In addition, NASA continues to perform independent research applicable to the FAA's missions. Progress in these areas will be assessed so that appropriate technology spin-offs can be incorporated within the national aviation system.

The Small Business Innovation Research (SBIR) Program will continue to play a key role in the FAA's RE&D activities. SBIR supplements ongoing RE&D with far-looking research that would not ordinarily be funded under existing projects.

2.1 NAS System Requirements

Responsible Division

ADS-100, Clyde Miller

Purpose

Ensure that national aviation system requirements are complete, cost-effective, and make the best use of available or foreseeable technology. Gather, evaluate, manage, and control the operational requirements of the national aviation system. Maintain and update requirements in a single baseline document and develop operational concepts for system functional areas.

Approach

Analyze requirements of airspace users and the operating services of the FAA in terms of costs, benefits, impacts to the aviation system and users, and technical risks. Validated requirements become a basis for research and development projects or enter the systems engineering process for implementation in the aviation system.

An operational system requirements document (NASSRS) is updated to reflect new or modified requirements. This document details the operational requirements for the aviation system as envisioned in 1995. Specific requirements and supporting analysis will continue to be developed in support of document maintenance and system development and design. NASSRS is the baseline requirements document.

Provide an analysis of evolving requirements and available technologies that dictate near-term and long-range enhancements to assure the future safety, productivity, and efficiency of aviation operations.

Products

- Aviation system operational requirements.
- Maintenance of the NASSRS.
- System function operational concepts.
- Requirements validation studies.
- RE&D projects defined.
- System engineering project definition.

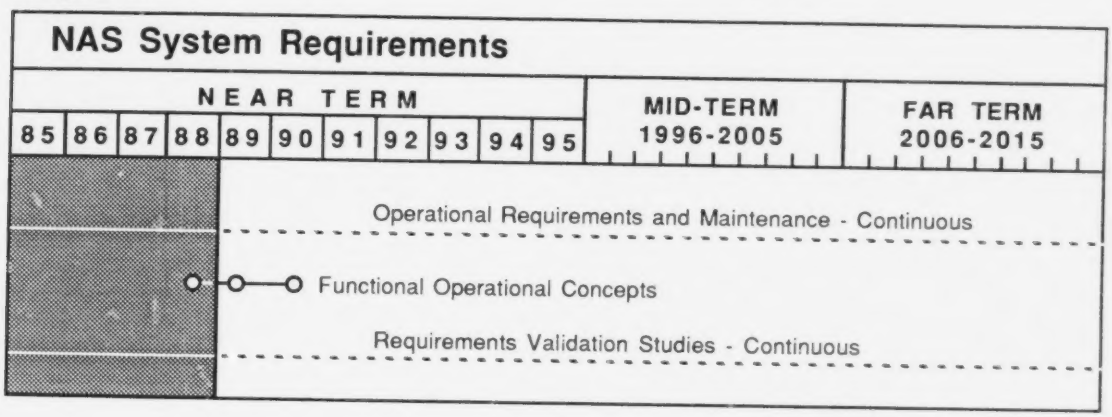
Recent Accomplishments

- The NASSRS has been baselined and changes 1 through 8 completed.
- Two operational concepts were issued.
- Six operational concepts were started.
- Analysis for the retention of en route primary radar was initiated.
- Reevaluation of the automated pilot advisory service concept was initiated.

Related Projects/Activities

All.

Project 2.1



2.2 Research, Engineering, and Development Plan

Responsible Division

AMC-200, James Rogers

Purpose

Provide a comprehensive description of research and development activities that will carry the FAA into the 21st century. The plan will document the FAA RE&D program and process.

Approach

An FAA RE&D Plan will be developed which describes the RE&D process, relationships with other RE&D organizations, the national aviation system and its evolution, and the FAA's RE&D program. The description of the FAA's RE&D program will include a top-down look at its major mission areas (capacity, safety, security, and efficiency), highlights of key programs, and a discussion of the relationships of the RE&D Plan to the NAS F&E Plan. Interaction with the aviation community will be encouraged to provide comments and recommendations on how the FAA should tailor its RE&D program to fulfill its missions. Individual projects will be reviewed in terms of budget and resource constraints.

The annual cycle will be:

Activity	Month
Draft plan preparation	1 - 6
User conference	7
Final plan published	9

Products

- RE&D Conference (annual).
- FAA RE&D Plan (annual).

Recent Accomplishments

- Development of 1988 RE&D draft publication.

Related Projects/Activities

- NAS F&E Plan.
- Airports Plan.
- Airport Capacity Improvements.
- Airport Capacity Enhancement Plan.

2.3 Management and Control Process

Responsible Division

AMC-200, James Rogers
ADS-1, David Johnson

Purpose

Provide visibility, accountability, and control of FAA RE&D activities. Develop and set in place a process and systems by which the FAA will monitor and control the RE&D budgets and programs and their interrelationships. Provide a means for more informed decisions by FAA management concerning the RE&D Plan and budget to best meet the total needs of the aviation community. Identify and develop products to support the future aviation system.

Approach

- Redefine the FAA's RE&D processes. This redefinition will include the earlier identification and validation of requirements; a review and approval process for new or modified programs, a review process for the oversight of existing programs; a periodic review and assessment of the status and viability of programs; and a series of symposiums, workshops, and conferences designed to obtain the views of the aviation community.
- Set up an RE&D Advisory Committee. The committee will be made up of representatives of a cross section of the aviation community. The committee will support the FAA in the development of new requirements or concepts; provide input and advice to the administrator on the RE&D Plan; and evaluate and provide advice to the FAA on special topics of interest to the community. The meetings will be open to the general public.
- Classify the FAA's RE&D requirements against the major mission areas of capacity, safety, security, and efficiency. Through a top-down analysis of the requirements and goals, the RE&D program will be defined and quantified. This will allow programs to be tracked against the requirements for each of the major mission areas, ensuring that there are few planning gaps and that the performance of each RE&D project can be managed.
- Establish an independent oversight group to evaluate the effectiveness of the FAA RE&D programs. This group will evaluate documentation of each RE&D project and perform independent analyses to either confirm or refute results, providing FAA management with an independent assessment of program performance.
- Develop new concepts, conduct new technology analyses and assessments, and plan and evaluate research activities in the following areas: airport technology, advanced systems design, advanced technologies, cockpit technology, and rotorcraft/tiltrotor systems.

Products

- RE&D development process.
- Establishment of RE&D Advisory Committee.
- Top-down analysis of major mission areas, requirements, and projects.
- Competitive procurement package for technical support.
- Improved air traffic control concepts and procedures to reduce delays and increase capacity.
- Improved standards.
- Applied technology.
- FAA RE&D project review process.
- Annual RE&D budget.

Recent Accomplishments

- Draft RE&D process.
- Draft order for the Advisory Committee.
- First-cut major mission area analysis.

Related Projects/Activities

- Research, Engineering, and Development Plan.

2.4 System Engineering Management

Responsible Division

ADS-100, Clyde Miller

Purpose

Provide an administrative and management framework for execution and control of FAA systems engineering projects. Ensure that necessary procedures, information, and training are available for effective management of projects.

Approach

Evaluate individual project needs and procure appropriate management, training, and support services necessary for the effective administration of projects.

Products

- Project management tools.
- Computer services.
- Training.
- Support service.

Recent Accomplishments

None.

Related Projects/Activities

- All systems engineering RE&D.

2.5 ADM Program Support/Management Initiatives

Responsible Division

AMC-200, James Rogers

Purpose

Provide management tools and procedures for use in monitoring, tracking, directing, and coordinating research and development activities.

Approach

- Define phased scope to be covered by management information system (MIS).
- Evaluate available management tools and procedures and determine applicability to ADM needs.
- Develop, procure, and implement specific tools or procedures to address needs identified through evaluation.
- Implement a computerized management information system. A phased approach will be used with most critical types of information and projects receiving priority.

Products

- Management information system.
- Department of Transportation reports.
- Smart sheets.
- Project resumes.
- RE&D 7-year budgets.
- Milestone reports.
- Public relations plans.

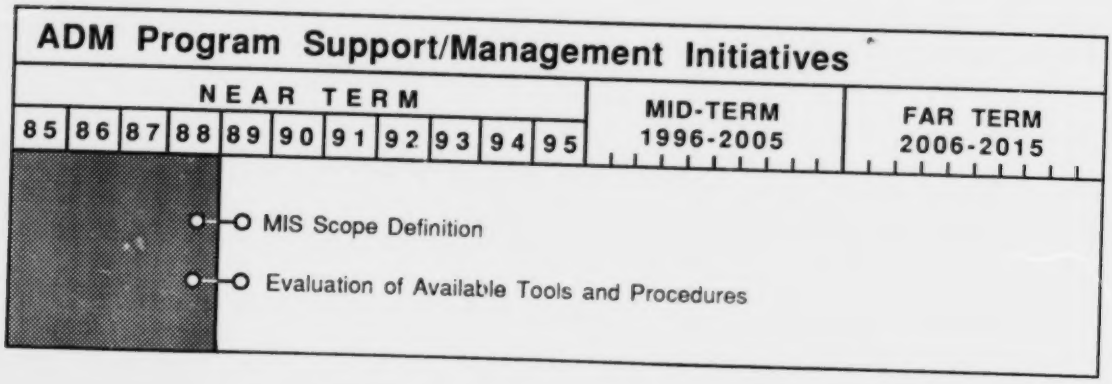
Recent Accomplishments

- Advanced management information system implemented for NAS F&E Plan development.

Related Projects/Activities

- Management information requirements study.
- Support contractor master scheduling tool.
- Support contractor cost management tool.

Project 2.5



2.6 Future System Definition

Responsible Division

ADS-200, William F. White

Purpose

Anticipate operational needs, develop new ideas and methods for the control of air traffic, and apply emerging technologies into an outline of future system concepts that will ultimately meet the requirements of the future aviation system.

The utilization of advanced technologies is aimed at highly sophisticated automated systems that will permit the pilot and controller to manage overall operations supported by automated systems and advanced sensors used to their fullest capabilities. Advances in communications, navigation, and surveillance could result in an advanced system which provides sophisticated worldwide capabilities without multiple independent ground elements.

Approach

Examine concepts and technologies that offer opportunities for developing improved aviation system capabilities in the post-2010 time frame.

- Conduct public conferences and workshops to elicit industry and user suggestions on future technological trades and concepts. The workshops will solicit recommendations on areas the FAA should pursue.
- Evaluate the feasibility of a concept's future operating scenarios. System designs of promising concepts will be developed, as necessary, in sufficient detail to permit analysis of their effectiveness and economy.
- Analyze operating scenarios of emerging new vehicles, including tiltrotors and supersonic and hypersonic aircraft.
- Consider new technologies for application in the future aviation system. These include very large scale integrated circuits combined with expert systems and ultrareliable computers; advanced satellite systems; and integrated, multiple sensor applications such as infrared and millimeter-wave technology.

Products

- Definition of a post-2010 aviation system concept.
- Estimation of future requirements and operating scenarios for the post-2010 time frame.
- Assessment of technologies applicable to future concepts.

- Descriptions of advanced concepts for air traffic services.
- Recommendations for new RE&D projects designed to develop promising technologies and concepts.
- System analyses that lead to optimal interaction among the components of the post-NAS F&E Plan system.

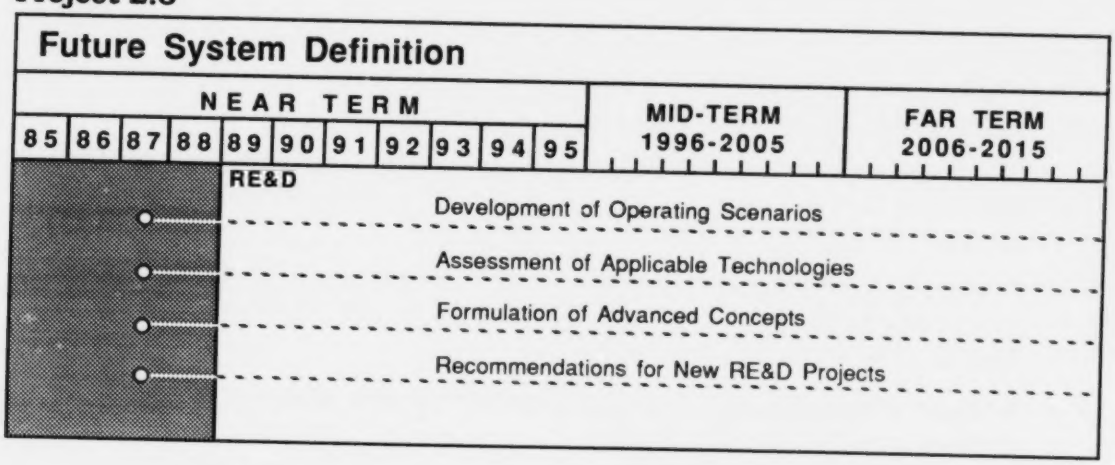
Recent Accomplishments

- 21st Century Symposium and Workshop.

Related Projects/Activities

- Research, Engineering, and Development Plan -- Focuses on the near and mid-terms, providing a background for future system definition.

Project 2.6



2.7 Simulation Model Development and Validation (SIMMOD)

Responsible Division

AOR-200, David E. Winer

Purpose

Provide a cost-effective, timely, and comprehensive analysis tool for national aviation system requirements and programs; to do this, it is necessary to develop and enhance the airspace and airport simulation capabilities of the model. Increase ease of use and efficiency of data preparation. Develop training and documentation on model use. SIMMOD is expected to play a significant role in future development of the national aviation system by identifying the most appropriate airport and terminal airspace design and procedural alternatives.

Approach

The prototype of SIMMOD will be modified to include a number of logic enhancements that will increase realism in simulating the actual behavior of the air traffic control system and airline operations. The time and effort needed to prepare input scenarios will be reduced by establishing automated means of digitizing airspace and airport data and by other computerized methods of acquiring schedule and traffic information. Visual replay of scenarios will be developed as an effective quality-control technique and for specific site calibration. Full documentation of the model's algorithms will be provided, as well as training manuals and courses, so that the model may be widely used by the FAA and others to improve designs and procedures in the national aviation system.

Products

- Executable computer program for microcomputers and mainframes.
- An organization of users throughout the FAA and industry.
- Training manuals and technical documentation for users.

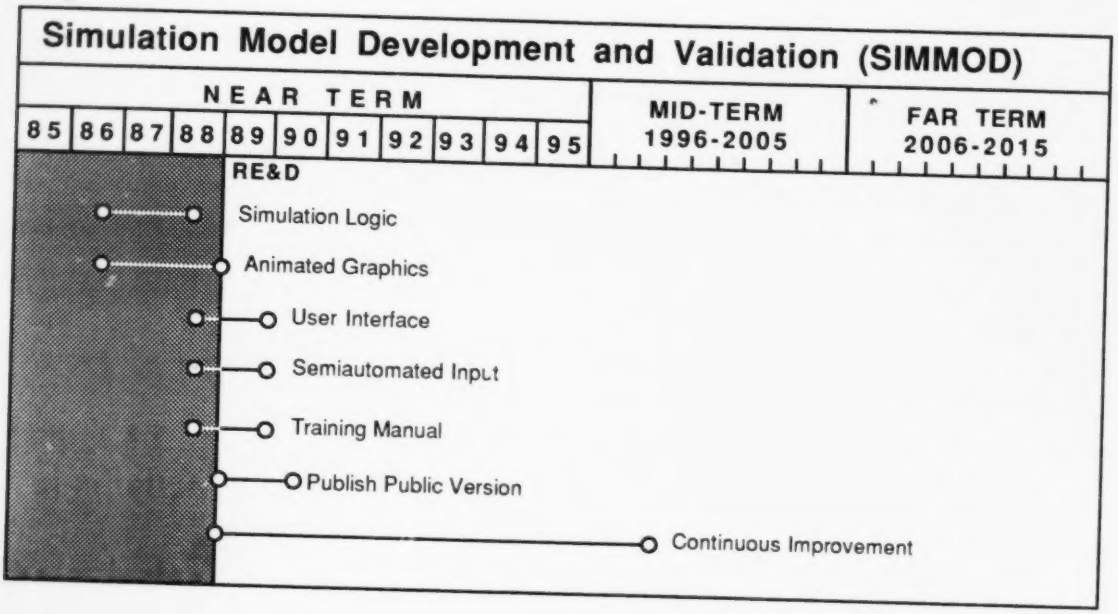
Recent Accomplishments

- Identification of all remaining tasks needed to produce a public release version of SIMMOD.
- Application of the model to numerous airspace design tasks by the FAA.
- Application to airport improvement studies by consultants.
- Development of prototype pre- and post-processing graphics.
- Los Angeles Basin initial airspace design.

Related Projects/Activities

- Airport Capacity Improvements.
- Airspace design.

Project 2.7



2.8 National Airspace System Performance Analysis Capability (NASPAC)

Responsible Division

AOR-100, Herbert Goldstein

Purpose

Achieve a long-term analysis capability through the application of modern tools of operations research and computer modeling to the development, design, and management of the nation's airspace on a systemwide level. This capability will identify the limiting factors in national aviation system performance and provide quantitative analysis to determine the impact of proposed changes on the overall aviation system while offering useful information to decision makers and strategic planners.

Approach

NASPAC is based on a simulation and analytical queuing model: The simulation model simulates discrete events that model the movement of individual aircraft through the nationwide network of airports, navigation fixes, routes, and sectors; the analytical queuing model is based on classical mathematical formulas of queuing theory. These models are being developed in two phases. The first phase of development incorporates the general structure of the national aviation system as a system of 58 selected airports and 48 arrival and departure fixes. The second phase enhances the simulation model by adding an en route representation, the effect of instrument meteorological conditions at airports, and additional details.

Both phases of the two prototype models are being designed, developed, and tested. They will be validated by comparing their results with real-world data on system performance. The prototypes will be expanded in scope. They will then be applied to several specific system performance questions. In the near term, the impact of airline hubbing, proposed new airports, and preferred flight routes in the national aviation system will be analyzed. Improvements in airspace design and management will be direct results of these efforts. The models will be enhanced, as required, for specific FAA applications regarding system performance. NASPAC will be reviewed for possible expansion to a national simulation facility.

Products

- Validated prototype.
- Model demonstration.
- Model documentation and validation.
- NASPAC Enhancement Plan update.

- DFW Metroplex application.
- New and old Denver airport applications.
- Chicago airport application.

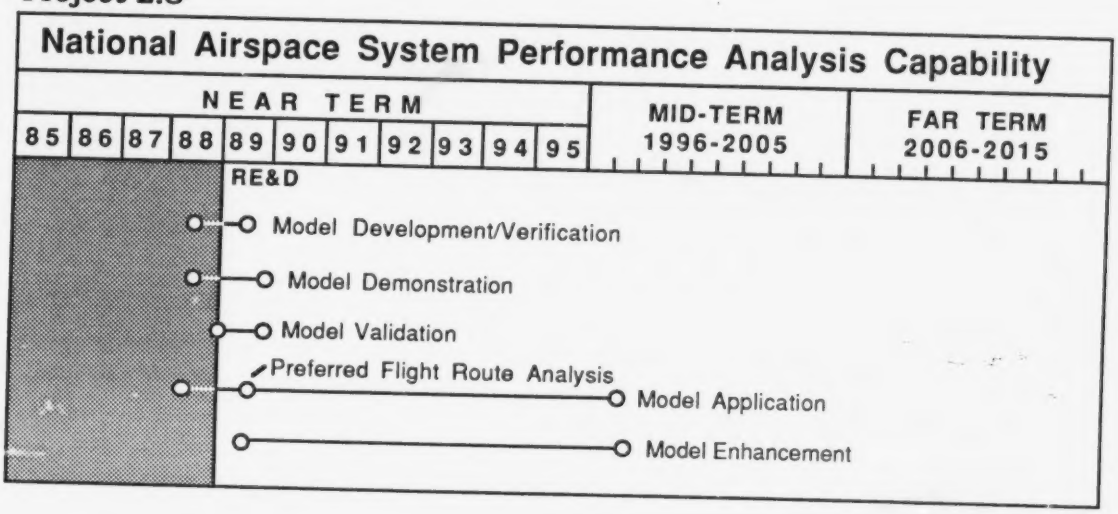
Recent Accomplishments

- NASPAC Enhancement Plan update.
- NASPAC demonstration program.

Related Projects/Activities

- Airspace System Models.
- Simulation Model Development and Validation (SIMMOD).

Project 2.8



2.9 Airspace System Models

Responsible Division

AOR-100, Herbert Goldstein

Purpose

Provide analysis capability of proposed aviation system changes. Develop a comprehensive aviation system capability. The model will support a national simulation testbed.

Approach

This project will develop analytical models and apply optimization techniques for evaluating future system changes. Models will be used to analyze the system impact of new equipment, air traffic control procedural changes, revised airspace configurations, and weather. Efforts will include the development of various databases, such as aircraft capability (by type), aircraft itineraries, airport limitations, and air traffic control procedures.

The model development process includes surveying existing modes, identifying system requirements, developing a system design specification, and preparing an implementation plan.

Products

- System requirements definition.
- System design specifications.
- Model cost and feasibility determination.
- Model prototype.

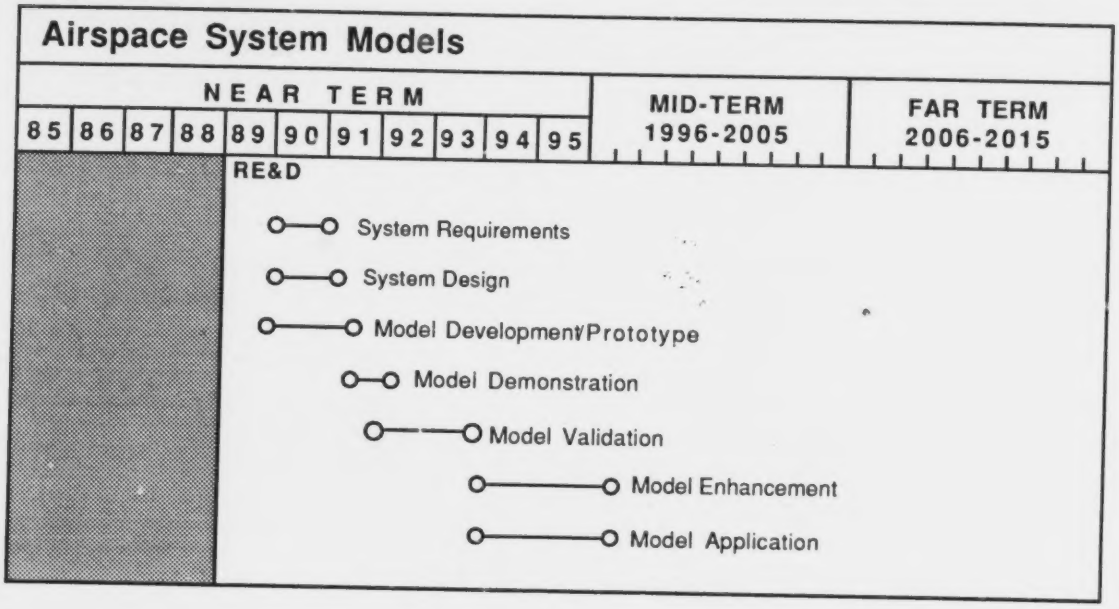
Recent Accomplishments

New start in FY 1990.

Related Projects/Activities

- National Airspace System Performance Analysis Capability (NASPAC).
- Simulation Model Development and Validation (SIMMOD).

Project 2.9


Airspace System Models
NEAR TERM
85 86 87 88 89 90 91 92 93 94 95
MID-TERM
1996-2005
FAR TERM
2006-2015
RE&D
System Requirements
System Design
Model Development/Prototype
Model Demonstration
Model Validation
Model Enhancement
Model Application

2.10 Joint University Air Transportation Technology Program

Responsible Division

ACL-1, Albert A. Lupinetti

Purpose

Pool resources with NASA in areas of common interest. Develop the personnel needed to develop and manage the components of the future aviation system.

Approach

Award research grants via a contract to three universities: Massachusetts Institute of Technology (MIT), Ohio University, and Princeton University. These research programs are intended to be interactive, especially on a student-to-student basis, and build on the particular strengths of each of the universities. The program is consistent with the interests of the FAA and NASA in furthering the safety and efficiency of the national aviation system and developing a cadre of technical people.

Over several years, active programs of education and research at the three universities have provided a strong base on which to continue to build research efforts related to air transportation technology. Current activities include artificial intelligence applications in air traffic control and aircraft systems, integrated navigation system, icing studies, data collection and analysis systems, windshear microburst analysis, and system simulation techniques.

Products

- Annual research report of completed projects.
- Quarterly research conferences at universities, FAA, and NASA.
- Doctoral dissertations and masters theses on aviation-related topics.
- Research studies on diverse aviation system projects.

Recent Accomplishments

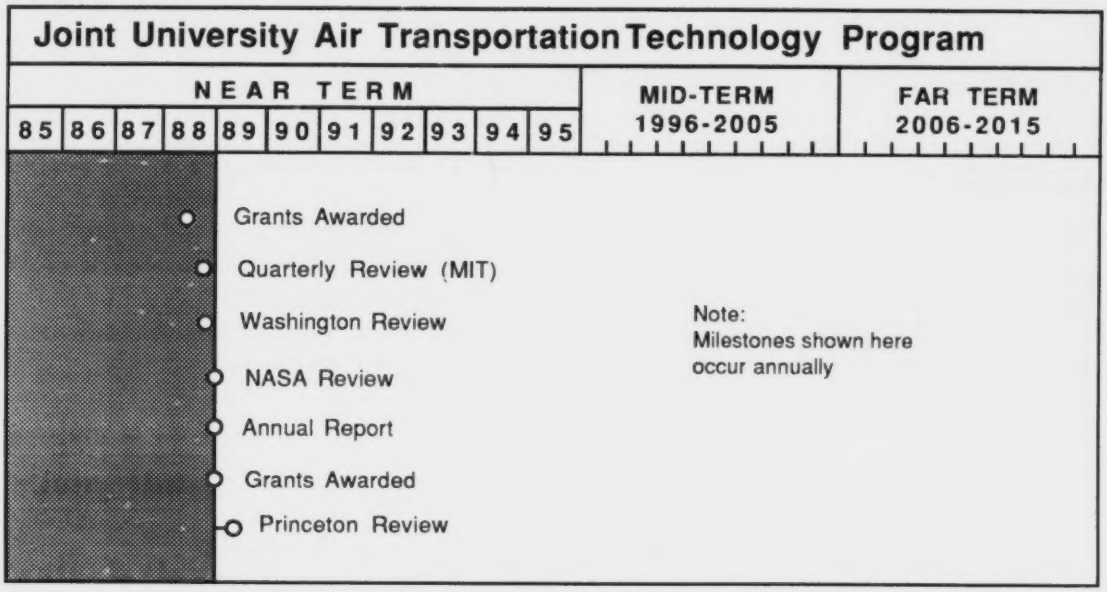
- Optimal control strategies for windshear penetration.
- Reliability studies of integrated navigation systems.
- Development and licensing of an acoustic aircraft icing detector.
- Design of a low-cost, advanced technology general aviation aircraft prototype.
- Research leading to increased understanding of the thermophysics of ice accretion.

- Information compression schemes for uplink of weather and traffic information to the cockpit.
- Development of an expert system to assist airport tower operations (Tower Chief).
- Codeless extraction of navigational information from the global positioning system.

Related Projects/Activities

The program contributes to the entire spectrum of FAA RE&D programs.

Project 2.10



2.11 Transportation Research Board

Responsible Division

APO-100, Norman Weil

Purpose

Stimulate research concerning the nature and performance of transportation systems, disseminate the information produced by the research, and encourage the application of appropriate research findings. The Transportation Research Board is a unit of the National Research Council, which serves the National Academies of Sciences and Engineering.

Approach

Award research contracts to the Transportation Research Board. This program is carried out largely by committees, task forces, and panels staffed by industry, public officials, and university experts who serve without compensation. The Board's efforts will include research on the future of aviation, a graduate research award program on technical and management innovations for civil aviation facilities in the next century, a study of the relationship between deregulation and air service changes, and other special research projects to further the safety and efficiency of the national aviation system.

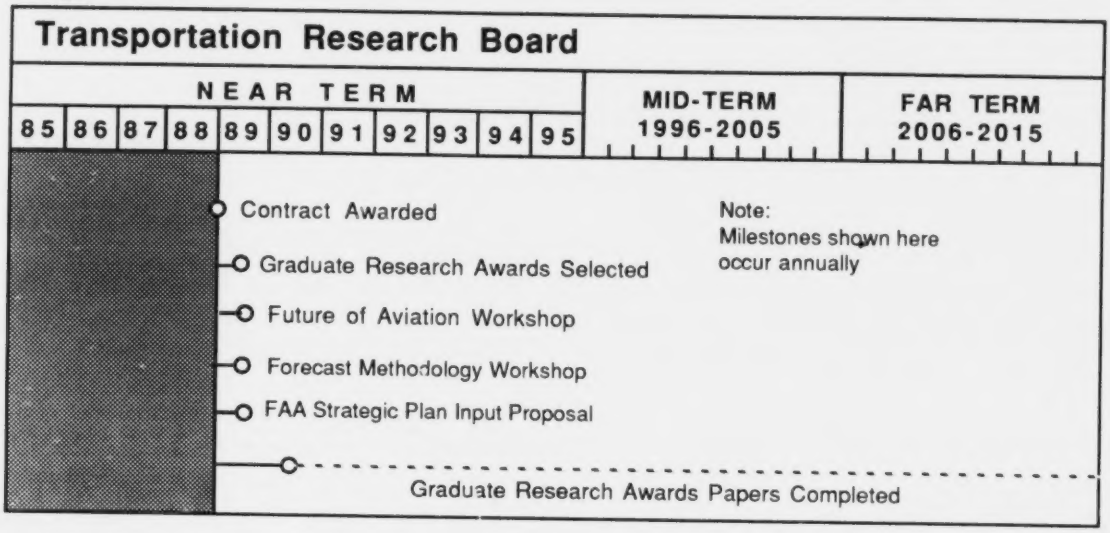
Products

- Biennial workshop - Future of Aviation.
- Graduate research papers.
- Forecast methodology workshop.
- FAA Strategic Plan input.

Recent Accomplishments

- Grants awarded to five graduate students.
- Aviation industry workshop held in October 1987 on the future of aviation.

Project 2.11


Transportation Research Board
NEAR TERM
85 86 87 88 89 90 91 92 93 94 95
MID-TERM
1996-2005
FAR TERM
2006-2015
Contract Awarded
Graduate Research Awards Selected
Future of Aviation Workshop
Forecast Methodology Workshop
FAA Strategic Plan Input Proposal
Graduate Research Awards Papers Completed
Note:
Milestones shown here
occur annually

2.12 Small Business Innovation Research Program

Responsible Division

ACL-1, Albert A. Lupinetti

Purpose

Utilize the research and development talents of the small business community in addressing the real needs which arise in the course of modernizing the national aviation system.

The program's goals are to stimulate technological innovation, use small business to meet federal research and development needs, increase private-sector commercialization of innovations derived from federal research, and foster and encourage the participation of minorities and the disadvantaged in the development of technological innovations.

The SBIR Program is congressionally mandated by the Small Business Innovation Development Act of 1982 (P.L. 97-219) and is scheduled to run until at least 1993. It is funded through a 1.25 percent assessment of the agency's extramural RE&D budget.

Approach

Supplement near-term, applications-oriented RE&D projects with innovative, far-looking research. Such long-term research (as distinguished from basic research for which the FAA is not chartered) would not ordinarily be performed under existing programs. SBIR also complements FAA research and development efforts by filling in gaps and offering alternative avenues of investigation for various programs.

Research topics are solicited from the various technical specialty groups throughout the agency. These groups then serve as evaluators of the technical quality of each proposal submitted. The following three-phase process is applied to those firms selected for an award:

- Phase I is for the conduct of feasibility-related experimental or theoretical research, or for RE&D efforts up to $50,000.
- Phase II is for principal research efforts having a period of performance of approximately 2 years and funded up to $300,000.
- Phase III is to be conducted by the small business without federal funds, with the purpose of pursuing commercial applications of research funded in Phase I and II by the Department of Transportation.

A noteworthy feature of the program is its ability to apply either allocated SBIR funds or project funds to accomplish research and development tasks. This flexibility, in addition to the minimal administrative cost of initiating projects, provides a high level of responsiveness to agency needs.

Products

- Annual agency report.
- Monthly and final project reports.
- Patent licenses.
- Annual Small Business Administration report to Congress and the President.
- Hardware and software deliverables.

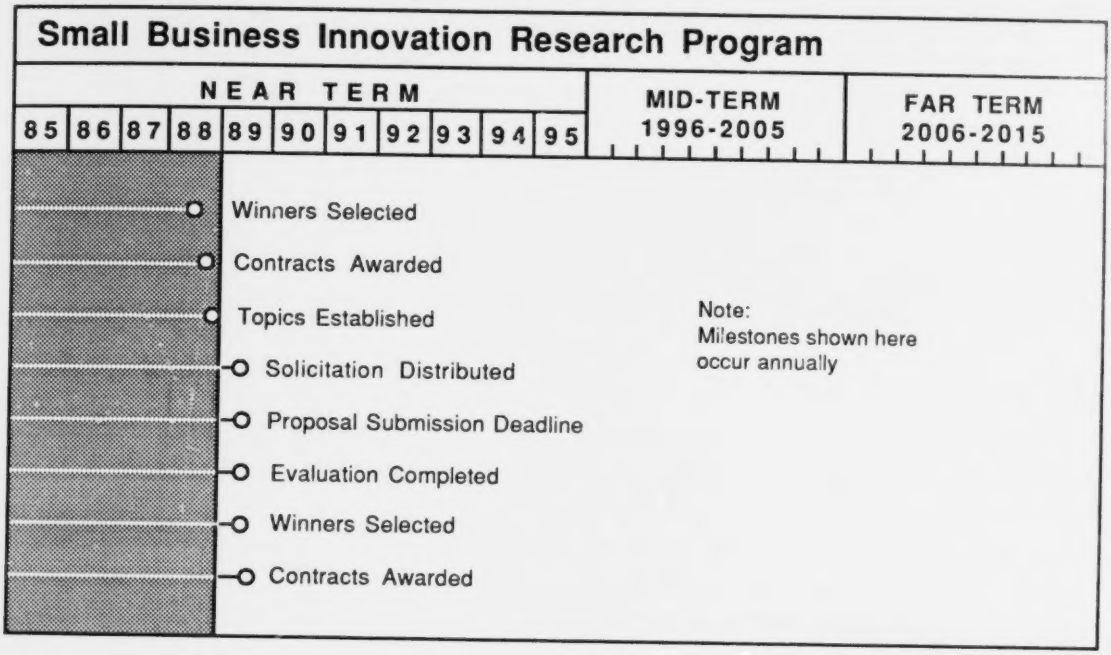
Recent Accomplishments

- Ultramaneuverable, nonstallable tandem-wing light aircraft.
- Expert system, processor, and display for use in training air traffic controllers.
- Electronic gauge for measuring the deterioration of runway pavements.
- Design and construction of an aircraft optical windshear detector.
- Fabrication and testing of an advanced airport surface icing detector.
- Research and construction of an ultraprecise, all-electronic baro-altimeter.
- Development of wake-vortex analysis and simulation programs.

Related Projects/Activities

- Aircraft safety.
- Aviation security.
- Avionics.
- Air traffic control and flight services technology.
- Aviation medicine.
- Human factors.

Project 2.12


Small Business Innovation Research Program
NEAR TERM
85 86 87 88 89 90 91 92 93 94 95
MID-TERM
1996-2005
FAR TERM
2006-2015
Winners Selected
Contracts Awarded
Topics Established
Solicitation Distributed
Proposal Submission Deadline
Evaluation Completed
Winners Selected
Contracts Awarded
Note:
Milestones shown here
occur annually

2.13 FAA/NASA Cooperative Programs

Responsible Division

ADS-100, Clyde Miller

Purpose

Provide the most cost-effective RE&D program by working with NASA on programs of mutual interest. Utilize NASA research, facilities, and personnel as appropriate.

Approach

Capitalize on independent research being conducted at NASA research centers, cosponsor research of joint interest, and make use of unique NASA facilities to achieve FAA RE&D program goals.

The FAA cooperates with NASA on programs of mutual interest by contributing funding to NASA's in-house research programs, conducting research projects in joint partnership with NASA, and conducting independent research in NASA facilities using FAA personnel. Projects in the first two categories are accomplished by means of memoranda of understanding for basic areas of work with interagency agreements setting forth specific research projects to be accomplished. To support joint FAA/NASA projects and provide coordination for NASA work, FAA field offices have been established at NASA's Ames and Langley Research Centers. The FAA personnel stationed at the field offices also conduct independent FAA RE&D tasks when the nature of the research falls outside of NASA's charter or resources. The field offices represent a unique resource for the FAA because of their proximity and access to NASA facilities, their knowledge of NASA personnel, and their understanding of FAA needs.

FAA field offices located at the NASA centers identify potentially beneficial lines of research that can contribute to the FAA's missions. Some of the work falling in this category includes the following:

- Natural laminar flow -- Investigation of the possible impact of the loss of laminar flow on the stability, control, and handling qualities of modern aircraft that have been designed to achieve large amounts of laminar flow. This could have an important bearing on certification of new aircraft. Flight tests will be completed in FY 1989.
- Wake-vortex detection -- Preliminary studies are under way to assess the feasibility of a prototype airborne system that would detect wake vortices. The effort will carry out limited flight tests to assess basic system practicality. A preliminary flight study of the practicality of proposed concepts will be completed in FY 1989.

- Microwave landing system (MLS) procedures -- Numerous studies have been conducted pertaining to MLS operations, including the simulation and flight testing of MLS curved and segmented approach paths, terminal instrument procedures (TERPS) data collection for transport aircraft, and MLS missed approach and departure simulation studies. In addition, a simulator study was conducted to provide operational evaluations of a variety of scenarios for increasing system capacity and reducing controller workload through the use of MLS traffic patterns in the New York terminal area.

- Rotorcraft technology -- Several studies are under way to examine present helicopter instrument flight rules (IFR) certification procedures and search for ways to improve instrument flight capability.

In addition to direct field office activities, cooperative research is being conducted at the NASA centers in the following general areas:

- Airborne windshear detection and avoidance studies -- In a joint program with industry and the FAA, NASA is participating in the development of system requirements for airborne, forward-looking windshear sensors for use on board aircraft. The work includes development and demonstration of technologies for sensing low-altitude windshear and addresses flight management issues relating to cockpit displays and flight controls.

- Aircraft/airport compatibility -- Basic runway surface traction characteristics are being studied using generic jet transport tires on various simulated runway surfaces at Langley's landing dynamics track. Measurements of tire traction and braking effectiveness will be made. Previous work in this area established a correlation between the performance of several types of runway-friction measurement devices and aircraft stopping performance.

- Cockpit technology -- Research addresses issues that link the aircraft with the national aviation system. Studies are being conducted in areas such as the application of knowledge-based systems technology to fault monitoring and diagnosis of aircraft systems, complex MLS/area navigation approaches, terminal area air traffic control automation, TCAS II human factors studies, and head-up display research.

- Storm hazards research -- Efforts will characterize the electromagnetic threat to aircraft, particularly the potential for lightning to affect or upset critical digital electronic systems aboard future composite materials aircraft. Langley conducted a number of flight tests in thunderstorms to collect data on the hazard. Additional work is targeted at correlating airborne and ground-based measures of severe storm hazards such as turbulence, lightning, and hail.

- Noise-reduction technology -- Investigations of means to reduce aircraft interior noise are under way. Also included are a survey of community responses and an investigation of means to reduce rotorcraft noise. An aircraft noise-predication program has been developed to model aircraft interior noise.

- Digital flight systems technology assessment -- New aircraft and systems are assessed to verify their intended function and specified performance, define failure modes and effects, and develop hardware and software validation procedures that are critical to the total safety certification process.
- Air traffic systems automation -- Research is in progress to define concepts for the highly automated air traffic control system of the future. The emphasis is on developing concepts for automating complex decision making and flow management in high-density airspace. Automation assistance is sought for traffic scheduling and spacing and for decision making in the limited terminal airspace. A particular challenge is the need to better integrate the roles of pilots, controllers, and air traffic control systems in the future environment.
- NASA Aviation Safety Reporting System -- This system collects safety-related data from pilots, air traffic controllers, and other members of the aviation community. Data are coded and collected in a database and used to detect trends and to analyze human performance in the operational environment.

Products

- Expert advice and technical data to FAA organizations and representatives to promote aviation and ensure system safety.
- Contributions to technical committees of the Radio Technical Commission for Aeronautics, American Institute of Aeronautics and Astronautics, International Civil Aviation Organization, and Society of Automotive Engineers.
- Operational and systems concepts for incorporation into the aviation system.

Recent Accomplishments

- Windshear characterization, detection, and avoidance system requirements.
- Runway surface traction characterization.
- Traffic Alert and Collision Avoidance System (TCAS) antenna performance modeling on various aircraft.
- Resolution of TCAS human factors issues.
- Assessment of MLS air traffic control procedures.
- Development of airworthiness criteria for supersonic and power lift aircraft.
- Documentation of the effects of wet radomes on signal transmission.
- Vertical format, vertical speed indicator evaluation.
- MLS curved and segmented approach paths simulation and flight testing.
- TERPS data collection for transport aircraft.
- MLS missed approach and departure procedures evaluation.

- Definition of heliport lighting requirements.
- Head-up display evaluations.
- Tiltrotor handling studies.
- Digital flight systems technology assessments.
- Systems support for the B-720 Crash Impact Dynamics Program.
- Noise-reduction technology (separate programs for aircraft interior noise, community response to noise, and rotorcraft noise).
- Data-link applications.
- Evaluation of nonlinear stability and control.
- Displays for decelerating IFR procedures in helicopters.
- Human factors evaluations related to pilot error inputs to flight management systems.
- Composite materials development and testing.

Related Projects/Activities

NASA, through its own funding, continues to perform research that is applicable and beneficial to the FAA mission in a number of areas, especially advanced technology. The FAA should monitor these areas so that appropriate technology spin-offs can be incorporated to meet existing problems in the aviation system.

Schedule

The program with NASA consists of numerous projects, each with its own schedule and planned products.

3. Air Traffic Control

There are 16 projects in the air traffic control (ATC) technical area, divided into 7 categories: flow management, en route ATC, terminal ATC, ATC procedures, separation standards, fuel utilization, and advanced automation concepts. These projects, which are listed below, support the capacity, safety, and efficiency mission areas.

Flow Management

3.1	Advanced Traffic Management System (ATMS)
3.2	Dynamic Special-Use Airspace Management

En Route ATC

3.3	Automated En Route Air Traffic Control 3 (AERA 3)
3.4	ATC Applications of Automatic Dependent Surveillance

Terminal ATC

3.5	Terminal ATC Automation (TATCA)
3.6	Airport Surface Traffic Automation (ASTA)

ATC Procedures

3.7	Airport Capacity Improvements
3.8	Rotorcraft/Power Lift Vehicles IFR Operations Evaluation
3.9	Rotorcraft/Power Lift Vehicles ATC Procedures

Separation Standards

3.10	Separation Standards
3.11	Wake-Vortex Avoidance and Forecasting
3.12	Rotorcraft Separation Standards

Fuel Utilization

3.13	Fuel Optimization: Dynamic Ocean Track System (DOTS)
3.14	Fuel Shortage Contingency Planning

Advanced Automation Concepts

3.15	Advanced Automation System (AAS)
3.16	System Concept Definition

In support of its ATC role, the FAA operates the flight service stations (FSSs), air route traffic control centers (ARTCCs), terminal radar approach control facilities (TRACONs), and airport traffic control towers, and provides communications, navigation, and surveillance (C/N/S) and weather services to civil and military users of the airspace. As indicated in the National Airspace System (NAS) Facilities and Equipment (F&E) Plan, many existing en route and terminal radar control facilities will be consolidated. Nonautomated FSSs will be absorbed into new automated facilities, and the Advanced Automation System (AAS) will replace en route and terminal automation hardware and software. The FAA will continually develop the hardware, software, and procedures needed to use the systems provided by the NAS F&E Plan as aids to ATC personnel in better meeting user needs.

The current ATC system comprises two main functions: a strategic function in the form of traffic flow management and a tactical function ensuring aircraft separation through planning and control of individual aircraft from departure to landing.

Flow management is the process by which traffic demand is allocated to the available system capacity at any given time. It is strategic in nature, since it considers variables at an aggregate level for a relatively long period (2 or more hours) into the future. Specific functions include monitoring and projecting air traffic demand and capacity, identifying potential imbalances, determining and implementing traffic management strategies, and making relevant traffic flow restriction and delay information available to users.

The tactical ATC function, on the other hand, attempts to minimize constraints on individual flights while maintaining required aircraft separation. This process begins with the initial ATC clearance and continues through all phases of the flight. The function is tactical in nature because it relates to a limited number of aircraft covering a small portion of airspace, usually involving a lookahead period of less than 30 minutes. The tactical ATC function may be further divided into en route and terminal functions.

This chapter focuses exclusively on those projects which will enhance FAA services and user benefits through automation capabilities directly supporting the ATC process. The perspective is that of the ATC operation, not that of the supporting technology. Projects support improvements in the following areas:

Flow Management

The principal objective of these projects is to create the automation capabilities that will permit the ATC system to ensure safety while imposing minimum constraints on system users and aircraft operations. The role of flow management in ATC is to consider the total demand placed on the system and to determine the best strategies for accommodating that demand. The Advanced Traffic Management System (ATMS) project will be aimed at developing the automation tools needed to enhance the precision, effectiveness, and timeliness of those strategies. ATMS is developing real-time prototype capabilities to (1) monitor and display the position of every instrument flight rules (IFR) aircraft operating in the domestic ARTCCs, (2) project the positions of those aircraft and alert flow managers to areas of potentially significant traffic congestion, (3) automatically generate or select alternative flow management strategies that will resolve traffic congestion problems, (4) automatically tailor and transmit flow management directives to impacted ATC facilities, (5) analyze the effectiveness of the selected flow strategies in real time as

a feedback loop, and (6) provide users with information on current flow management and delay conditions.

A second important area is the operational utilization of special-use airspace (SUA). The dynamic interaction between the FAA and the Department of Defense (DoD) will be fundamental to ensuring that civil and military user requirements for the airspace can be satisfied efficiently. This project will analyze operational requirements and develop the prototype technology needed to permit close FAA/DoD coordination of SUA utilization.

En Route ATC

The en route role of ATC is to accommodate the demand placed upon the en route functions (adjusted by flow management) while ensuring aircraft separation. The Automated En Route Air Traffic Control 3 (AERA 3) project will develop a tactical planning function that will allow updated and refined strategic flow management information. AERA 3 will also provide the automation support that will enable the ATC system to safely accommodate the operational requirements of aviation users.

Automatic dependent surveillance (ADS) will use an aeronautical satellite-based data link to report aircraft-derived positions to ATC centers during oceanic flight. The availability of these surveillance data will enhance the safety and efficiency of ATC operations in oceanic regions, wherein there is no direct radar coverage.

Terminal ATC

The Terminal ATC Automation (TATCA) project will develop automated traffic planning and coordination capabilities. These capabilities will permit a reduction in terminal area delays and an increase in terminal system capacity, while reducing controller workload and better accommodating user-preferred descents and approaches.

The Airport Surface Traffic Automation (ASTA) project will focus on reducing the frequency of taxiway and runway incursion incidents.

ATC Procedures

In order to more fully utilize airport runway capacity and reduce operating constraints on users in en route and oceanic airspace, additional ATC procedures will be developed. Procedures for airports with multiple runway configurations, including reduced-spacing parallel runways, converging and intersecting runways, and triple runways, will make additional airport capacity available under instrument meteorological conditions (IMC). Techniques will be developed for the use of navigation and surveillance systems in support of new procedures; these techniques will involve more accurate and more frequent surveillance of landing aircraft to ensure safety. The development of rotorcraft ATC procedures will improve services for rotorcraft and civil tiltrotor aircraft and allow full utilization of their operational capabilities.

Separation Standards

Onboard navigation capabilities of aircraft will be evaluated in an effort to reduce vertical separation standards from 2000 to 1000 feet for altitudes above 29,000 feet (FL290). Rotorcraft separation standards will also be validated.

Wake-vortex research will evaluate and revise separation standards to more accurately reflect potential hazards.

Fuel Utilization

Aviation fuel conservation will be encouraged through the development of algorithms for computing optimum flight trajectories based on aircraft operating characteristics, wind and weather conditions, and traffic loads. Simulations will be used to model airport and airspace traffic conditions and procedures. A prototype flexible track system will be applied in the oceanic environment. In addition, a second project will assess the impact of a disruption in oil supply on air transportation.

Advanced Automation Concepts

Projects in this area will provide for management of the AAS and develop a comprehensive vision of the future ATC system.

3.1 Advanced Traffic Management System (ATMS)

Responsible Division

ASA-200, Carey L. Weigel

Purpose

Reduce delays and improve operating efficiencies by developing an automated traffic management system that matches demand to available capacity.

Approach

The ATMS will link terminal, en route, and national traffic management functions to enhance traffic management capabilities and provide more precise information to system operators and users on current and projected congestion conditions. Functions are discrete, allowing for continuous operational implementation. ATMS will have the capability to accurately monitor the aviation system, provide alerts on projected congestion, generate alternative traffic management strategies, and distribute associated flow directives to ATC facilities. The project will develop the following specific functions:

- Aircraft situation display (ASD) -- A real-time display of all IFR and selected visual flight rules (VFR) aircraft positions that will provide the user with multiple methods of aircraft selection and highlighting, as well as the capability for post-analysis traffic replay.
- Monitor alert -- Will maintain an accurate database containing the current status of all IFR and selected VFR air traffic. The monitor alert will continually compare demand versus capacity for all airports, en route sectors, and selected en route fixes. When projected demand exceeds capacity, this function will generate an alert specifying the condition and the time frame in which it is forecast to occur.
- Automated demand resolution -- Will automatically provide traffic management alternatives for resolving identified imbalances between demand and capacity. These alternatives, which may include reroutings, flow rate adjustments, or ground delays, will enable the traffic management specialist or automated system to select the flow strategy that best achieves the desired overall system performance. The algorithms for this function will be evaluated through air traffic simulations and field tests.
- Strategy evaluation -- Will evaluate the alternative flow strategies against a given set of operational parameters.
- Automated message distribution -- Will provide automated distribution of flow management directives to other FAA facilities based on the demand resolution strategy selected.

The ATMS project will also include the following:

- Definition of system performance indices -- Will examine operational data on proposed and actual arrival and departure times, controlled departure times issued by central flow control (CFCF), and similar data. Air traffic operations will be simulated to define a consistent set of system performance indices, including delays in the air and on the ground, controller and pilot workload, and extra aircraft fuel consumption. Indices will be used to upgrade CFCF algorithms and to assist traffic management specialists in evaluating and selecting alternatives for resolving predicted traffic imbalances.
- Performance analysis function -- Will perform an ongoing, real-time analysis of the flow control strategies initiated in response to a given situation. The results of this analysis, as well as data from the en route ATC functions, will be used by the system to adjust flow strategies in order to optimize the desired result. Additionally, the analysis will be used by the automated demand resolution function to determine options for future alternative selections.
- Direct user access to traffic management system information -- Will develop capabilities in the CFCF computer to provide users with traffic management information such as delays, flow restrictions, and the status of special-use airspace. Users will have direct access to this information through the flight service automation system, the AAS, or the CFCF database.
- Oceanic traffic management -- Will specifically address flow management issues related to oceanic airspace. Functional and operational requirements for improved oceanic traffic management will be defined, working toward an integrated domestic and oceanic flow management system.

Products

- Functional specifications for the ASD.
- Functional specifications for monitor-alert function.
- Functional specifications for automated demand resolution function.
- Functional specifications for strategy evaluation function.
- Functional specifications for automated message distribution function.

Recent Accomplishments

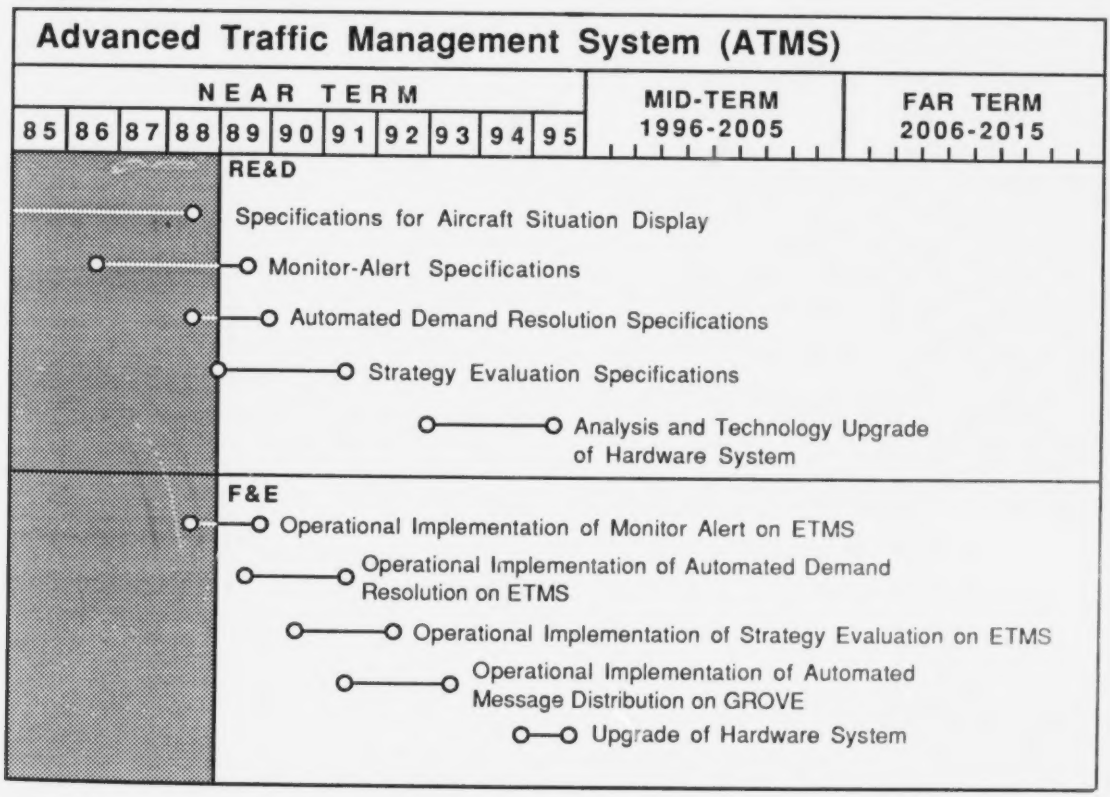
- Implementation of distributed processor and enhanced traffic management system (ETMS).
- Development, testing, and implementation of the ASD in central flow control.
- Development, testing, and implementation of monitor-alert function in central flow control.

- Implementation of ASD at the Los Angeles and Chicago ARTCCs and the Chicago TRACON.
- Implementation of prototype satellite link for the transfer of flow-control data.

Related Projects/Activities

- Automated En Route Air Traffic Control 3 (AERA 3) -- Required to ensure the precision of projected traffic conditions and the effectiveness of flow management strategies.
- Airport Surface Traffic Automation (ASTA) -- Will provide CFCF with estimates of departure delay levels and aircraft acceptance rates.
- Central Weather Processor (CWP) -- Provides traffic management specialists and coordinators with current and predicted weather information.
- Weather research supporting the stormscale operational and research program -- Will provide ATMS and AAS with improved data and forecasts for winds aloft.
- Dynamic Special-Use Airspace Management -- Will provide guidelines for evaluating the impact of the activation and release of special-use airspace on national or local traffic management.

Project 3.1


Advanced Traffic Management System (ATMS)
NEAR TERM
85 86 87 88 89 90 91 92 93 94 95
MID-TERM 1996-2005
FAR TERM 2006-2015
RE&D
Specifications for Aircraft Situation Display
Monitor-Alert Specifications
Automated Demand Resolution Specifications
Strategy Evaluation Specifications
Analysis and Technology Upgrade of Hardware System
F&E
Operational Implementation of Monitor Alert on ETMS
Operational Implementation of Automated Demand Resolution on ETMS
Operational Implementation of Strategy Evaluation on ETMS
Operational Implementation of Automated Message Distribution on GROVE
Upgrade of Hardware System

3.2 Dynamic Special-Use Airspace Management

Responsible Division

ASA-200, Carey L. Weigel

Purpose

Develop procedures and define automation requirements for increasing flexibility in SUA allocation and use. The FAA is working closely with DoD, which has the lead in developing a military airspace management system.

Approach

The activation and release of SUA, such as restricted airspace and military operations areas, are currently limited by several factors, including manual interagency coordination. The allocation and control of SUA are therefore not always totally responsive to either military or civilian needs. New ATC procedures and the necessary automation requirements will be developed for improved management of SUA. This project will be divided into several tasks, as follows:

- Interagency coordination procedures are being examined in FY 1989 to identify functional and performance requirements for a more dynamic SUA management function. A draft report on SUA operational procedures, current limitations, and recommendations for improvement will be completed in FY 1990. This report will form the basis for further development activities and for integration with the national ATC flow management process.
- Requirements will be developed for the database structure and communications necessary to dynamically manage SUA.
- Requirements will be developed for the necessary ATC automation at both the ATMS and AAS levels to support improved SUA operational procedures. Automation requirements will cover several technical areas, including:
  - Assessment of the national and local impacts of the activation and release of SUA, based on number and identity of aircraft affected. Flow management alternatives will be examined that will reduce the number of and degree to which aircraft are affected.
  - Dynamic definition of SUA to satisfy emergency or high-priority requirements.
  - Accommodation of noninterfering military user-preferred trajectories (UPTs) to and from a SUA at the area control facility (ACF) level.
  - Assessment of the national and local impacts of reroutes around a specified SUA.

Products

- Report on SUA operational procedures, current limitations, and recommendations for improvement.
- Report on SUA air traffic control database and communications requirements.
- Report on SUA for ATC automation functional requirements.

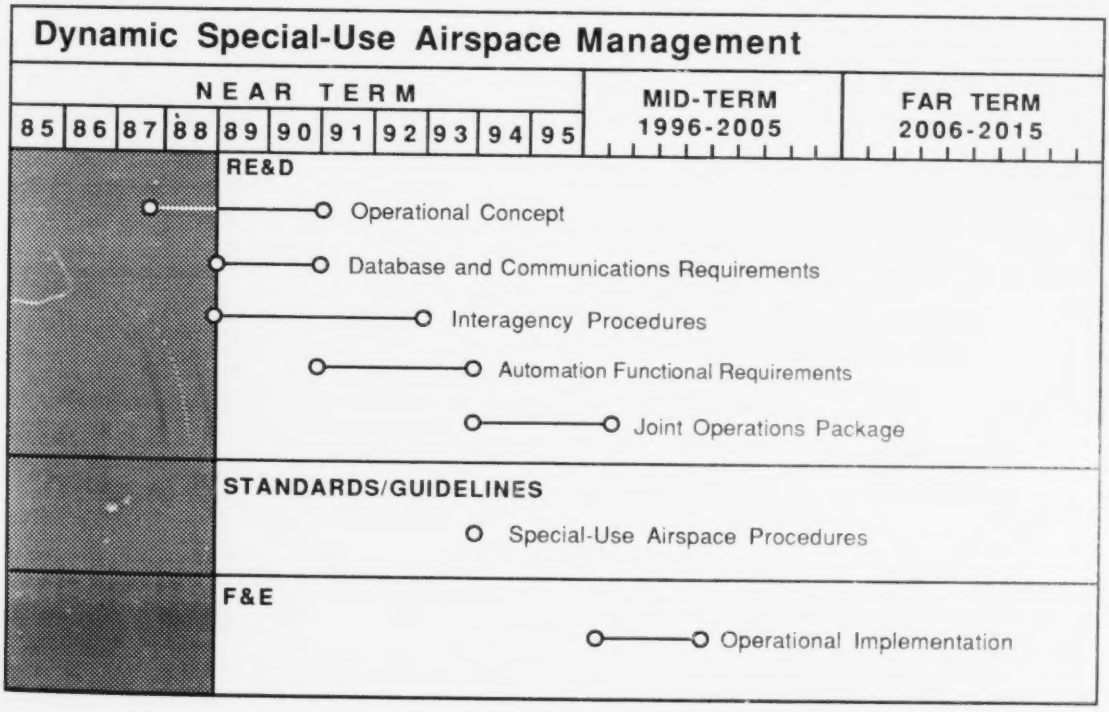
Recent Accomplishments

New start.

Related Projects/Activities

- Automated En Route Air Traffic Control 3 (AERA 3) -- Will provide capabilities for assessing the impact of military traffic.
- Advanced Automation System (AAS, NAS F&E Plan) -- Will provide traffic management information for assessing the impact of SUA activation and alternate reroutes around the active SUA.
- Advanced Traffic Management System (ATMS) -- Will interface to ensure the most effective use of airspace.

Project 3.2



3.3 Automated En Route Air Traffic Control 3 (AERA 3)

Responsible Division

ADS-100, Clyde Miller

Purpose

Develop automated en route air traffic control (AERA) as a means to increase the efficiency and safety of aircraft operations and the productivity of controllers in the en route environment. AERA has four objectives:

- Accommodate users' requests for preferred IFR flight plans, i.e., preferred routes, altitudes, and speeds.
- More fully utilize available airspace capacity.
- Augment system productivity, i.e., increase the effective number of aircraft and volume of airspace handled per air traffic control team.
- Preserve or enhance system safety by minimizing the potential for system errors.

Approach

AERA will use the AAS computers and new software to monitor the planned flight profiles of all controlled traffic for potential conflicts, to calculate resolutions for predicted flight path conflicts, and to communicate clearances to aircraft to assure safe, fuel-efficient aircraft operations.

The development of AERA 3 is the final stage of an incremental approach.

AERA 1 primarily enables users to fly UPTs more frequently. It supports probes for predicting potential violations of separation standards, monitors special-use airspace and traffic flow restrictions, and helps supervisors balance sector traffic by providing sector workload predictions. AERA 1 also provides controllers with lists for quickly constructing and evaluating clearances, flight plans, reminders, and reconformance aids.

AERA 2 extends AERA 1, providing an automated problem resolution capability and automated aids to facilitate coordination among controllers. When a problem is detected, AERA 2 automatically generates several resolutions. The controller is then able to select the one that best suits the plans for the sector airspace. AERA 2 also accommodates, via data link, computer-generated, controller-approved clearance delivery.

AERA 3 is being developed to exploit the application of automation to the process of air traffic control in order to better accommodate user-preferred flight trajectories and increase controller productivity. It will assist with the task of individual aircraft separation, operating in a totally integrated partnership with ATMS and supported by terminal ATC, departure flow management, and runway configuration management systems. Within this partnership, AERA 3 will expeditiously plan, organize, monitor, and control the safe and efficient movement of aircraft through en route airspace.

With AERA 3 automation performing the job of safe aircraft separation, the ATC system will no longer be limited by a controller's capability to maintain the "big picture." Today's sectors will be combined into larger volumes, called AERA regions, managed by an ATC specialist. This specialist will strategically interact with the AERA 3 system to control aircraft flows. At the same time, in response to the automated detection and resolution of potential conflicts, AERA 3 will be generating and issuing, via data link, the clearances necessary to maintain safe separation of all positively controlled aircraft operating within the system. AERA 3 will take advantage of the capabilities of advanced airborne flight management systems (FMSs) and advanced navigation avionics, in order to accommodate FMS-derived profiles while meeting any necessary ATC restrictions. With AERA 3 operating in conjunction with the ATMS, positive controlled airspace will be structured so that ACF failures can be automatically backed up in a safe manner that will be virtually transparent to the airspace system user. The net result of AERA 3 is that the airspace system user will realize substantially more frequent approval of UPTs, even in the face of heavy traffic loads.

The AERA 3 baseline concept was developed with extensive support from FAA field operations and system users. The baseline was then broken down into discrete core functions for evaluation and development.

Prior to a production commitment, prototype core functions will be designed, developed, integrated, tested, and evaluated for operational integrity, failure mode recovery, and safety, using extensive simulations and operational personnel. Production systems will be rigorously tested and operationally validated in the FAA's technical research facility and at each field site prior to full deployment. In FY 1989, the development of the baseline AERA 3 system and operational concepts will culminate in a demonstration of a simulated AERA 3 operational environment. In FY 1990, as a result of these efforts, design development will be initiated and will result in a preliminary AERA 3 system-level specification. Experimentation and testbed evaluations will be conducted at the contractor's laboratory to examine the major operational and technical implications of a highly automated ATC system.

Products

- AERA 3 system concept (operational and engineering perspectives).
- AERA 3 system-level functional/performance definition (A-level specifications).
- AERA 3 engineering development requirements definition (B/C-level specifications).
- AERA 3 preproduction software model procurement package.
- AERA 3 preproduction software model.

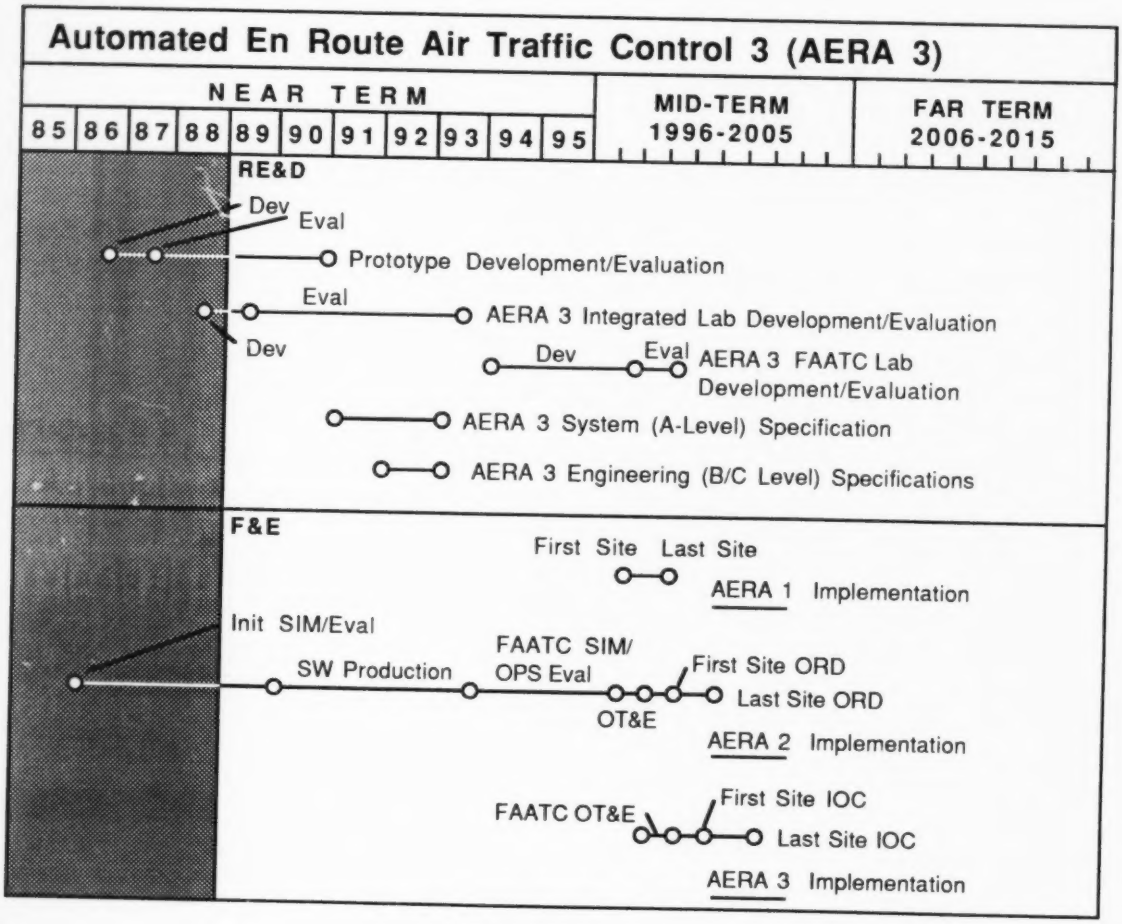
Recent Accomplishments

- Defined baseline AERA 3 systems concept.
- Established AERA 3 stand-alone prototype lab demonstrations of functional capabilities.
- Initiated coordination activities with users and industry.

Related Projects/Activities

- Advanced Traffic Management System (ATMS) -- Will issue traffic management restrictions for compliance by AERA.
- Central Weather Processor (CWP) -- Will provide accurate wind data and weather forecasts.
- Data-link applications development -- Mode S data link, interfaced through the AAS, will provide automated controller and pilot data and advisory interchange.

Project 3.3



3.4 ATC Applications of Automatic Dependent Surveillance

Responsible Division

ASA-200, Carey L. Weigel

Purpose

Exploit the ADS function as a means for improved ATC operations in oceanic and domestic environments, including the increased safety and efficiency of flight operations.

Approach

Oceanic ATC operations are today conducted manually, with controllers monitoring aircraft flight progress based on voice position reports from flight crews. Aircraft must adhere to rigid route structures, and relatively large separations must be maintained to accommodate navigation inaccuracies and the lack of accurate position reports at frequent intervals. The resulting airspace capacity limitations and the inability of controllers to approve flight plan changes force aircraft to operate on less efficient routes. Similar problems exist for offshore and low-altitude domestic airspace.

The ADS system will permit tactical and strategic control of aircraft. Automated position report processing and analysis will result in near-real-time monitoring of aircraft movement. Automatic flight plan deviation alerts and conflict probes will support increased safety, reductions in separation minima, and increased accommodation of user-preferred routes and trajectories. Graphic display of aircraft movement and automated processing of data messages, flight plans, and weather data will significantly improve the ability of the controller to manage oceanic air traffic.

This program will be developed in incremental steps, the first being navigation blunder detection. The second step will add the two-way digital data link for air traffic command and control. Follow-on steps will add other features, including conflict detection, digital voice, and automated conflict resolution, all leading to safer and more efficient use of the airspace.

In FY 1989, ADS Step 2 performance requirements will be completed. These requirements will serve as the basis for the Step 2 system specifications and operational concepts that will be completed in FY 1990.

Testing that includes the ATC ground facility, simulation facility, and communications satellite data link will continue through FY 1993.

Products

- Requirements definitions for the detection, separation, navigation, and control of aircraft in oceanic airspace.
- Operational concept.
- Operational requirements.

- Display requirements for an oceanic control system using dependent surveillance inputs.
- Technical requirements for avionics.
- Technical requirements for data link.
- Safety analysis.
- Specifications for an oceanic control system.
- Test plans and procedures.
- Study reports on dependent surveillance improvements.
- Study reports on system comparisons.
- International Civil Aviation Organization (ICAO) system standards.
- Cost-benefit analysis.
- Study report on domestic applications.

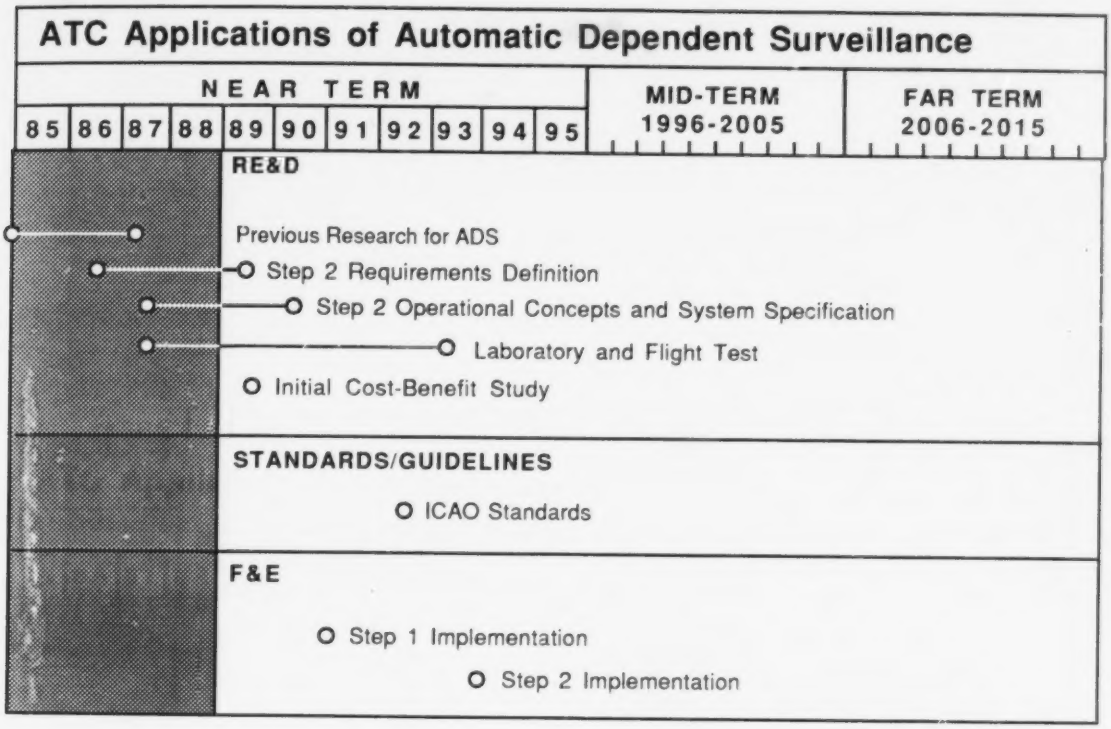
Recent Accomplishments

- Operational concept defined for application of ADS in oceanic environment.
- System specification developed for ADS Step 1.

Related Projects/Activities

- Oceanic Display and Planning System (NAS F&E Plan) -- Will provide a baseline for controller display and aids in oceanic ATC.
- Advanced Automation System (AAS, NAS F&E Plan) -- Oceanic ATC will be incorporated in the AAS.
- Low-Altitude Surveillance -- Will utilize the basic concepts of ADS.
- Satellite-Based Air-Ground Communications -- Will provide air-ground communications system for ATC voice and data transmission.
- Future Communications Requirements and Architecture --Will provide a plan for evolving from the present interfacility communications system hybrid architecture to an all-digital architecture.

Project 3.4


ATC Applications of Automatic Dependent Surveillance
NEAR TERM
85 86 87 88 89 90 91 92 93 94 95
MID-TERM
1996-2005
FAR TERM
2006-2015
RE&D
Previous Research for ADS
Step 2 Requirements Definition
Step 2 Operational Concepts and System Specification
Laboratory and Flight Test
Initial Cost-Benefit Study
STANDARDS/GUIDELINES
ICAO Standards
F&E
Step 1 Implementation
Step 2 Implementation

3.5 Terminal ATC Automation (TATCA)

Responsible Division

ADS-100, Clyde Miller

Purpose

Develop ATC automation aids for ATC supervisors and controllers to maximize the use of terminal airspace and increase the efficiency of aircraft operations in and out of terminal areas. Explore the potential for increasing user and operator productivity by incorporating time-based ATC concepts.

Approach

Develop time-based traffic control concepts to accommodate aircraft operations along flexible approach paths in accordance with operator schedule constraints and aircraft performance characteristics. These flexible, time-based approach paths have the potential to significantly improve aircraft operating efficiencies and terminal area capacity during periods of heavy demand.

TATCA is a major development effort that will be accomplished through the development of three specific functions:

- Traffic planner/coordinator -- A computer-resident traffic planning and coordination network will form the core of the initial automation package. The traffic planner will generate a plan for efficient aircraft movement within an appropriate time horizon, satisfying operational metering and flow control constraints and accommodating uncertainties.

  ATC coordination will be facilitated by sharing the traffic plan and its associated database among all relevant supervisory and control positions. Data link will allow transmission of relevant information to the participating aircraft. A customized local display of the plan will be provided to each controller position.

  Automatic plan updates based on radar surveillance data will reflect changes in aircraft locations and speeds. The plan will derive current traffic demand information from surveillance, flight plan, and manual input data (e.g., runway configuration, visibility, and hazardous weather). It will use this information to suggest metering rates and other important planning measures to supervisory personnel. A plan conformance indicator will display the amount of time by which each aircraft has deviated from the schedule.

  Planning accuracy will be capable of enhancement, as more accurate estimates of local winds aloft become available. The planner will be designed to use the best sources of wind information available in a given terminal environment, starting with today's unaugmented wind data and advancing through a sequence of improvements. The first improvement, adaptive wind determination, will employ

aircraft trajectories to refine the wind estimate. The second will employ new wind sensors, such as a wind profiler or terminal Doppler weather radar. The final improvement will employ automatically and continuously downlinked wind data from aircraft traversing the planning airspace.

An important feature of the traffic planner will be its ability to calculate efficient landing sequences. In IMC, when traffic demand is heavy, the traffic planner will suggest possible aircraft landing orders that will reduce average in-trail spacing by exploiting predictable differences in landing intervals caused by factors such as wake-vortex separation and landing speed.

Important longer range research efforts will also be initiated to facilitate an enhanced ATC environment in which airborne automation will allow the user to assume more responsibility for assisting ATC planning and precisely complying with the formulated plan. This research will focus on the exploitation of four-dimensional-equipped aircraft, digital data link, advanced cockpit avionics, improved weather products, and AAS capability.

- Descent advisor -- Another tool to be investigated in the initial package will be a descent advisory that includes such information as where descent should begin and what speeds should be flown. This function will save fuel in visual meteorological conditions, as well as IMC, by allowing appropriately equipped aircraft to fly, where possible, uninterrupted, fuel-efficient, conflict-free, and accurately timed descents from cruise altitude to the final approach fix. The focus of this effort will be, once more, on planning and coordination to allow participating control sectors to handle the descent without interruption and to ensure that no conflicts occur.

- Final-spacing advisor -- The final-spacing advisor will suggest specific speed changes or turn-to-final commands for bringing the aircraft into compliance with the plan and for more precisely spacing aircraft on final approach. The converging approach delivery aid, a specific application of the final-spacing advisor, will assist controllers in feeding staggered approach streams to converging runways, thus allowing more beneficial use of converging approaches under IMC conditions.

As work progresses, the above early automation features will be enhanced with further automation aids. The descent advisor will ensure that aircraft can employ fuel-efficient descents from cruise altitude and arrive at the metering fixes at times consistent with the overall plan for terminal sequencing. Radar controllers will be provided with speed advisories that simplify the process of keeping aircraft in conformance with the traffic plan. Procedures based on data link will also be developed to ensure smooth and efficient flight progress with minimal controller intervention.

Each of the above early candidate automation features will be integrated into a realistic, real-time simulation testbed for preliminary evaluation of operational suitability by active controllers. Because the principal focus of initial efforts will be the development of terminal automation techniques that can be used in the pre-AAS environment, the testbed will include current-day controller workstations with monochromatic plan view displays and manual flight strip handling. Auxiliary TATCA processing (and possibly auxiliary displays) will be required

for the new automation functions in the simulation. Where possible, this equipment will employ up-to-date commercial technology representative of planned AAS equipment.

Field evaluation tests will also be conducted using auxiliary TATCA processors interfaced with sources of live surveillance and flight plan data. Processors will distribute the TATCA planning and advisory data to a network that will include displays for the TRACON supervisor and sector controllers.

A simulation testbed will be assembled to provide an early capability for simulating the performance of terminal automation aids, using processors and controller-machine interfaces characteristic of those specified for the AAS environment. The hardware, software, and interfaces of this testbed will serve as a prototype for later phases of the program, when the focus of the effort will shift to the generation of terminal automation software specifically for the AAS environment.

In FY 1989, development of system designs is being initiated for the dynamic traffic planning, aircraft descent profile advisory, and final approach spacing advisory automation features. Real-time simulations will be conducted to develop and assess the performance, benefits, and probable costs of implementing these designs.

In 1989, a laboratory evaluation will be completed of the automated controller display aid required to support dependent approaches to converging runways. Preparations will begin for operational evaluation of a prototype system in 1990.

In FY 1990 through 1996, the dynamic traffic planning, traffic sequencing, and aircraft speed advisory capabilities will be integrated and evaluated in real-time simulations. Alternative controller display and input concepts will be analyzed, with a prototype system selected for demonstration at the MIT Lincoln Laboratory facility in 1991.

Products

- Automated traffic planner/coordinator.
- Automated descent advisor.
- Automated final-spacing advisor.
- Simulation testbeds.
- Prototype system.

Recent Accomplishments

- Identified initial terminal automation controller aids.

Related Projects/Activities

- Digital automated radar terminal system (ARTS) display -- In TRACONs with the new, fully digital ARTS displays, TATCA functions can utilize graphics capabilities to provide more advanced automation functions.

- Host computer -- TATCA software for en route transition sectors can be implemented, in part, in the host processor. The TATCA top-of-descent advisory and traffic planning functions are loosely related to existing and planned en route functions such as en route metering and the traffic management system. The design of first-level TATCA software will be closely tied to progress in the development of en route functions.

- AAS processing environment -- Eventually, all TATCA software will be implemented in AAS processors. The design and documentation of TATCA software will be managed to allow straightforward rehosting into the emerging AAS architecture.

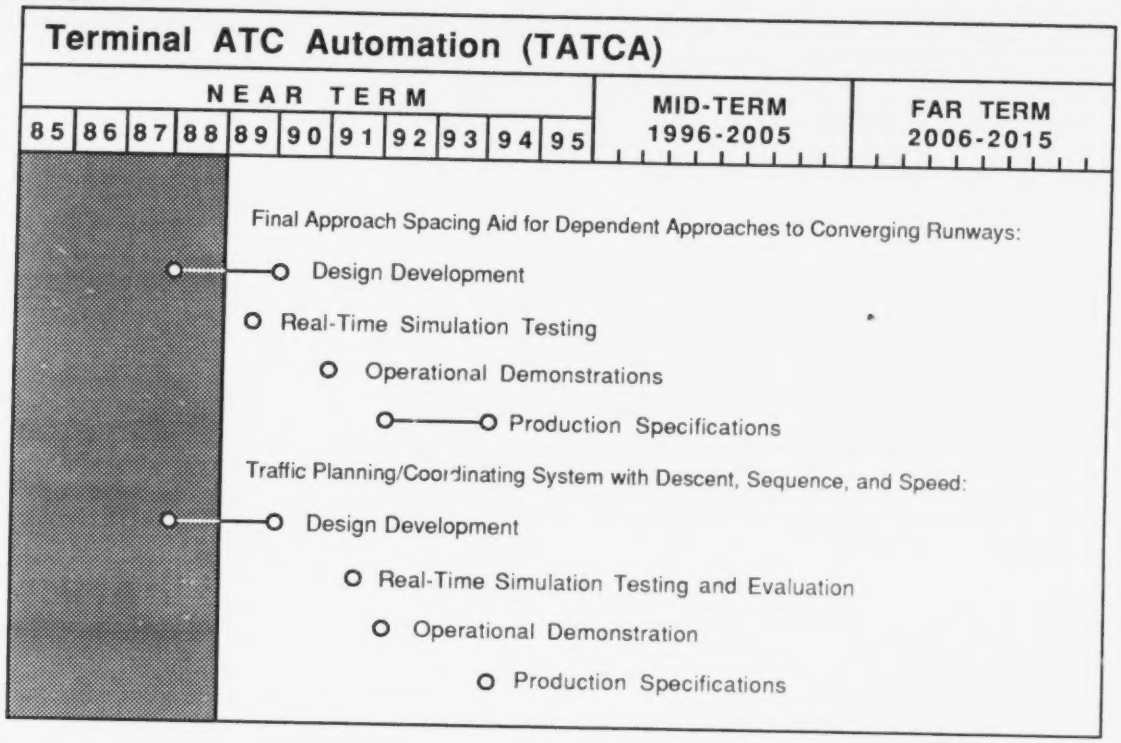
- AERA -- TATCA functions, such as traffic plan generation, plan-conformance indications, and control advisories, are conceptually related to planned AERA functions, even though the particular control strategies appropriate for terminal areas may be quite different from those for AERA. The design of TATCA software will be accomplished with close monitoring of the related AERA function designs.

- Weather projects -- Terminal automation planning will require accurate estimates of winds and weather along the terminal flight paths. Initially, TATCA automation will employ currently available wind data augmented by dynamic corrections derived from the analysis of surveillance radar data. If necessary to improve TATCA planning accuracy, data from external wind sensors will be employed when it becomes available. Ultimately, the downlinking of aircraft state data will be used for more accurate wind determination.

- ATMS -- TATCA will have an interface with the Advanced Traffic Management System to support integrated strategic planning. The principal role of TATCA in this regard is to allow TRACON personnel to provide the ATMS with more accurate and timely estimates of current and near-future terminal area throughput values.

- Mode S data link -- The Mode S data link will eventually be used for data transmission between controllers and pilots and between ground automation and airborne automation. Early terminal automation functions will not require data-link services. However, when Mode S becomes operational, terminal automation will use Mode S for several functions, including improved wind determination, determination of user intent, and issuance of advisories. Mode S protocols and data formats for these applications will be developed as part of the TATCA program.

Project 3.5


Terminal ATC Automation (TATCA)
NEAR TERM
85 86 87 88 89 90 91 92 93 94 95
MID-TERM
1996-2005
FAR TERM
2006-2015
Final Approach Spacing Aid for Dependent Approaches to Converging Runways:
Design Development
Real-Time Simulation Testing
Operational Demonstrations
Production Specifications
Traffic Planning/Coordinating System with Descent, Sequence, and Speed:
Design Development
Real-Time Simulation Testing and Evaluation
Operational Demonstration
Production Specifications

3.6 Airport Surface Traffic Automation (ASTA)

Responsible Division

ADS-100, Clyde Miller

Purpose

Apply ATC automation techniques to develop an effective runway intrusion alarm for ground controllers. Sequence aircraft to the departure end of the runway in accordance with schedules designed to expedite traffic flow out of the terminal airspace. Increase the capacity of the airport surface in all weather conditions.

Approach

The ASTA project will take a dual-approach, producing both near- and long-term products.

One path will focus upon immediate reduction of runway and taxiway incursion incidents. Documentation of airport accidents and incidents will be analyzed to focus on causal factors rather than incident-specific conditions. This analysis will serve as a basic foundation for technological solutions to fundamental and inherent operational problems and issues. One example of these efforts will be the development of software that alerts ground controllers, on a real-time basis, to potential problems based upon airport surface detection equipment radar data.

At the same time, long-term research on the operational and technical feasibility of automating the ground control separation assurance and traffic management functions will be developed. This effort will identify the functional requirements for using airport surface surveillance data, integrated with controller-defined routings, to guide aircraft through runway or taxiway intersections safely and efficiently. Alternative approaches for communications and surveillance will be evaluated. Algorithms that utilize these surveillance data and controller routings will be developed for probing and resolving potential airport conflicts by generating clearances. Conflict-prediction algorithms will be tested and evaluated through traffic simulations. A data link will be used for communications between the tower and vehicles. The use of the data link for the transmission of airport surface traffic routing control and go/no-go commands will be evaluated as part of this project. In addition, minimum surveillance and communications coverage and minimum surveillance update and accuracy requirements will be defined. The feasibility of using artificial intelligence techniques will be studied as well. Based on this information, a dynamic implementation will be developed and updated.

The following specific functions have been identified for development:

- Multiple airport dependent runway management will expand on the single airport system known as the runway configuration management system. It will include the capability to provide dynamic arrival and departure rates in support of managing a runway configuration selection subsystem. The program will consider those airports within hub areas that are runway- and airspace-interdependent.
- Predeparture queue management will provide an automated capability for the integration of airport airside traffic. Expansion of the logic developed under the departure flow management system will permit the application of more efficient taxiing routes and aircraft sequencing methodologies, thereby improving ground capacities and ensuring safety from runway incursions.

In FY 1989, work has begun on identifying alternative capabilities intended to reduce the frequency of runway incursions. In FY 1990, promising alternatives will be selected for more in-depth investigation and experimentation. This activity will serve as the basis for a phased development program that will concentrate on providing automated guidance and separation on the airport surface, with an initial focus on reducing runway and taxiway intrusion incidents.

Products

- Interim runway incursion alert system.
- Functional description of an airport surface conflict prediction system.
- Functional description of an airport surface guidance system.
- Testbed evaluation of ASTA functions.
- System specifications.
- Prototypes.
- Implementation plan.

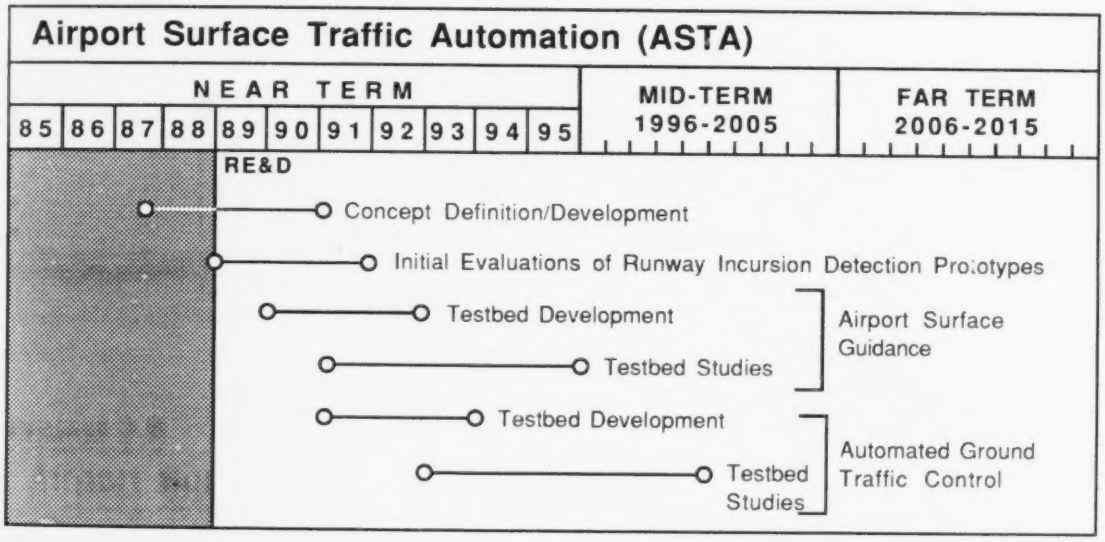
Recent Accomplishments

New start.

Related Projects/Activities

- Advanced Automation System (AAS) -- Will provide ASTA with the capability to communicate with the ACF's strategic and tactical planning function through the tower control computer complex.
- Automated En Route Air Traffic Control 3 (AERA 3) -- Is the major driver for traffic planning in the ACF. Through constant updates to the ATMS, ASTA's arrival and departure management programs will ensure the efficient movement of traffic.
- Surface Traffic Surveillance -- Will provide enhanced surveillance.

Project 3.6



3.7 Airport Capacity Improvements

Responsible Division

ADS-200, William F. White

Purpose

Develop ATC concepts and procedures to reduce airport delays, more fully utilizing the IMC capacity of multiple runway configurations. Design the requirements and techniques for improved surveillance and navigation capabilities to support these procedures, resulting in lower costs and improved service for airport users.

Approach

Recent studies sponsored by the FAA and the aviation industry have identified operational concepts with the potential to reduce airport arrival delays by better utilizing multiple runway configurations in IMC. These concepts apply to independent and dependent approaches to the following types of runways:

- Parallel runways with centerline spacings as low as 3000 feet.
- Converging and intersecting runways.
- Triple runway configurations, including configurations incorporating separate short runways.

ATC procedures and associated navigation and surveillance techniques for implementing the above concepts will be developed. Promising concepts will be further explored through ATC simulations and, in some cases, full-scale demonstrations at airports.

ATC procedures for IFR approaches in IMC to parallel runways with separations less than the current standard of 4300 feet are based on one or more of the following techniques:

- Dependent approach procedures, wherein aircraft on parallel approach paths maintain a prescribed radar separation.
- The use of precision surveillance systems for accurately monitoring the positions of aircraft on parallel approach paths to detect navigation blunders that could induce midair collisions.
- Microwave landing system (MLS) curved approaches, which ensure wider separation of approach paths, thereby permitting monitoring by existing airport surveillance systems.

Procedures under development for approaches to converging runways utilize flexible MLS missed approach guidance in addition to missed approach guidance from very high frequency omnidirectional ranges and nondirectional beacons, making possible independent approaches at lower minima than are possible today. In addition, procedures based on staggered, or dependent, approaches are under development.

Procedures for better utilization of triple runway configurations are based on those developed for converging and parallel runways. Specific proposals for triple runway procedures will be developed as the work on converging and parallel configurations matures.

Application of these techniques to specific airport environments will be studied. Planning and analysis will be done to ensure that the necessary RE&D programs are in place to identify and address all obstacles to increasing airport capacity.

In FY 1989, concept development and benefit assessments are continuing in the following areas:

- Flight procedures and system requirements for simultaneous IFR approaches to triple parallel runways.
- Development of operational concepts and system improvements that would support reduction of approach criteria for IFR approaches to converging runways.
- Development of operational procedures and system improvements that would permit use of improved diagonal spacing between aircraft for dependent parallel runway operations.

In FY 1990, evaluation of simultaneous IFR triple runway approaches will be completed based on computer simulations and controller participation. These simulations will include both triple converging and independent parallel approaches. A detailed plan will be developed for flight test demonstrations of these IFR approaches. By FY 1991, it is anticipated that a triple parallel runway will be available at an operational airport such as Dallas-Fort Worth to conduct triple parallel IFR demonstrations. These demonstrations, if successful, will lead to early implementation of triple IFR approaches, which would substantially reduce delays at some major hub airports.

Products

- ATC procedures for IFR approaches to multiple runway configurations.
- Surveillance and navigation requirements and techniques to support multiple instrument approach procedures.
- Results of analyses, ATC simulations, and field demonstrations of promising procedures.

Recent Accomplishments

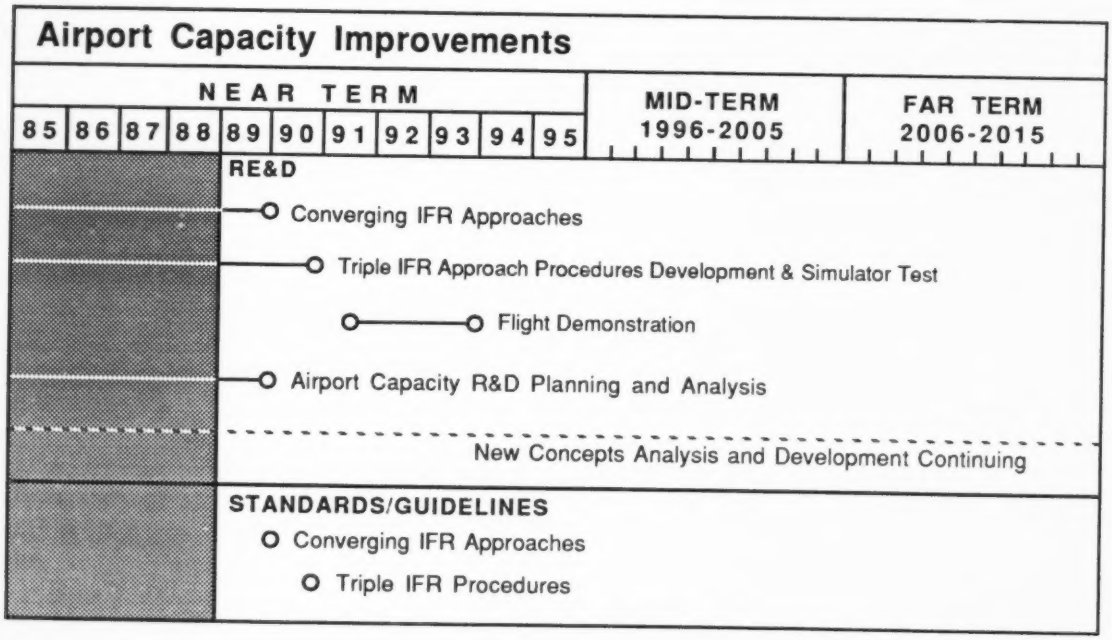
- Report on a procedure for operating dependent instrument approaches to converging runways completed.
- Report on runway placement options to support triple IFR approaches at Atlanta airport completed.
- Simulation of Dallas-Ft. Worth simultaneous quadruple IFR approach completed.

- Preliminary analyses performed of potential triple IFR approaches for specific airports.
- Report on a survey of potential site-specific applications of MLS completed.

Related Projects/Activities

- Precision Approach and Landing -- Will develop MLS curved and variable glide slope procedures, including those for missed approaches.
- Landing Monitor for Closely Spaced and Converging Runways -- Will develop surveillance techniques for monitoring closely spaced parallel approaches.
- Terminal ATC Automation (TATCA) -- Will develop controller automation aids to ensure aircraft separation in the event of simultaneous missed approaches to parallel and converging runways.
- 1988 Airport Capacity Enhancement Plan -- Provides the overall plan for increasing airport capacity and reducing delays.

Project 3.7



3.8 Rotorcraft/Power Lift Vehicles IFR Operations Evaluation

Responsible Division

ADS-200, William F. White

Purpose

Develop terminal approach procedures (TERPS) and airborne systems to allow full utilization of rotorcraft and civil tiltrotor operational capabilities.

Effective utilization of the rotorcraft and civil tiltrotor will require the ability to operate from vertiports with ready access to population centers and existing airports. However, present instrument procedures and TERPS are designed to accommodate the limitations of fixed-wing aircraft and older-technology C/N/S systems.

Approach

Research and development efforts for civil tiltrotor TERPS will concentrate on devising methods of safely utilizing this vehicle's capabilities in areas that present criteria do not allow. These flight capabilities, coupled with the accuracy and versatility of available navigation modes, are ripe areas of investigation. Once developed, TERPS criteria will expand aircraft operations to allow efficient use of the limited available airspace. This effort is partially dependent on definition of the vehicle performance parameters.

Performance parameters and handling qualities of tiltrotor aircraft will be modeled and system views of tiltrotor performance within the navigation and ATC systems will be developed. Particular emphasis will be focused on the conversion mode during which the civil tiltrotor operates between full fixed-wing and rotary-wing modes.

This project will determine the accuracies required for approaches, departures, and en route operations. Symbology requirements and display formats for control and navigation information will be identified, and appropriate applications for color displays will be determined. The operation of advanced displays and controls will be evaluated. Procedures will be developed to employ prototype heliport and vertiport lighting systems for precision approaches under low-visibility conditions.

Products

- Revised (and reduced) TERPS for rotorcraft operations.
- Performance models of the civil tiltrotor.
- Definition of minimum handling qualities for the civil tiltrotor.
- Airborne systems definitions for tiltrotor operations.

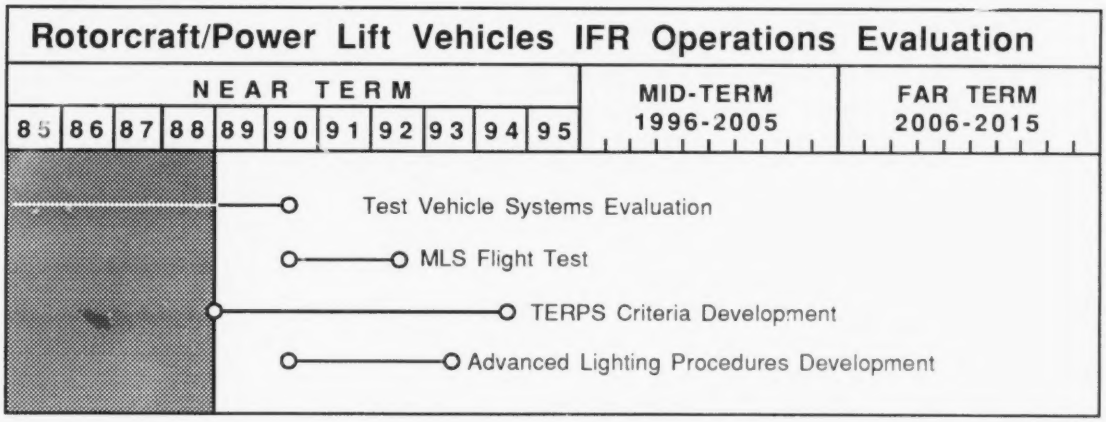
Recent Accomplishments

- Zero/zero certification issues forum and report.
- Heliport MLS sitting criteria.

Related Projects/Activities

- Rotorcraft/Power Lift Vehicles Obstruction Avoidance.
- Rotorcraft/Power Lift Vehicles ATC Procedures.
- Rotorcraft/Power Lift Vehicles Display and Control Studies.

Project 3.8



3.9 Rotorcraft/Power Lift Vehicles ATC Procedures

Responsible Division

ADS-200, William F. White

Purpose

Increase capacity through the prudent combination of airplane and rotorcraft air traffic and facilitate a more dynamic and responsive rotorcraft transportation segment. Develop procedures for the common usage of en route and terminal airspace that take advantage of the unique characteristics of rotorcraft to optimize system capacity.

Approach

In FY 1989, VFR and special VFR studies will be concluded, and work on terminal IFR operations will be initiated. Recommendations on ATC standards for a low-altitude route structure will be completed in FY 1990. Development of ATC procedures for simultaneous operations involving rotorcraft/power lift vehicles and fixed-wing aircraft will be completed. Recommendations will be provided to the Air Traffic Service in FY 1991.

Products

- Recommended procedural changes to enhance rotorcraft/power lift vehicle operations.

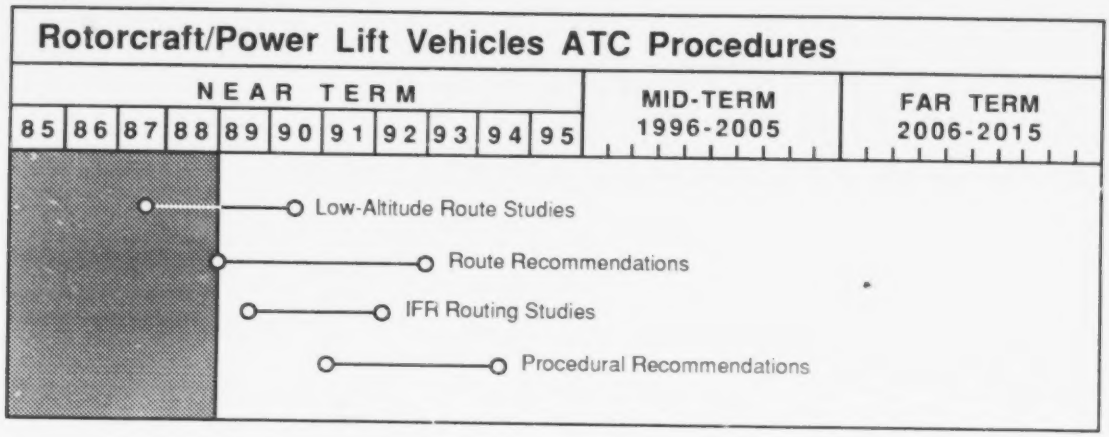
Recent Accomplishments

None - new start.

Related Projects/Activities

- Rotorcraft/Power Lift Vehicles IFR Operations Evaluation.
- Rotorcraft/Power Lift Vehicles Obstruction Avoidance.
- Rotorcraft/Power Lift Vehicles Display and Control Studies.
- Rotorcraft Simulator Standards.
- Heliport/Vertiport Design and Planning.
- Rotorcraft Separation Standards.
- Tiltrotor Certification Support.

Project 3.9


Rotorcraft/Power Lift Vehicles ATC Procedures
NEAR TERM
85 86 87 88 89 90 91 92 93 94 95
MID-TERM
1996-2005
FAR TERM
2006-2015
Low-Altitude Route Studies
Route Recommendations
IFR Routing Studies
Procedural Recommendations

3.10 Separation Standards

Responsible Division

ADS-100, Clyde Miller

Purpose

Review separation standards to ensure safety while reducing the minimum horizontal, vertical, and longitudinal separation standards. Reduced separation standards would enhance the overall flexibility and efficiency of the ATC system and support international decision making on worldwide separation standards.

Approach

Tests will be conducted to provide quantitative guidance for separation minima permissible in the ATC system so as to allow the most effective use of new technologies as they are introduced. This effort will also help establish separation requirements based on ADS, area navigation (RNAV), and other developing technologies for supporting reduced permissible separation minima.

The oceanic horizontal separation standards program will analyze separation standards in the North Atlantic, Central East Pacific, North Pacific (NOPAC), and West Atlantic route systems. It will examine the impact of various system improvements on safe minimal horizontal and longitudinal spacings for oceanic traffic. These improvements will include increased frequency and accuracy of position reports, ADS, aircraft turn intent and all-digital displays, and new avionics. As oceanic traffic becomes increasingly flexible through the automation of air traffic control, this program will establish appropriate separation standards to facilitate maximum traffic efficiency and safety.

Onboard, time-based navigation capabilities and associated ATC capabilities will be specifically analyzed in an effort to study the feasibility of time-based separation standards. (It must be noted here that separation standards for airport approaches are addressed in a separate project, Airport Capacity Improvements.)

The vertical separation program will examine whether the existing vertical separation minimum above FL290 can be reduced from 2000 to 1000 feet. Such a reduction in permissible vertical separation would provide the ATC system with enhanced flexibility to accommodate UPTs and would lead to substantial savings in user costs.

Data have been collected and are being analyzed in an effort to determine the height-keeping performance of aircraft above FL290 and to evaluate aircraft certification criteria, aircraft altimeter systems, altimeter certification, and altimeter systems maintenance. Tests will be conducted to assess the safety of reduced vertical separation minima and to establish altimetry certification criteria, aircraft equipment requirements, and operational and monitoring procedures.

In FY 1989, an effort will be initiated between the United States and the ICAO to prepare worldwide guidance material for implementing reduction of vertical separation standards above 29,000 feet to 1000 feet. In FY 1990, a data package to support rulemaking within the U.S. will be prepared.

In FY 1989, the draft ICAO guidance material for worldwide RNAV procedures and separation standards will be completed and submitted to ICAO for international approval. Safety analysis is being initiated in FY 1989 to investigate the airspace protection area for the inside of turns at airway intersections and the required navigation performance capability. This work will continue through FY 1990 in support of the review of general concepts of separation panel and the North Atlantic special planning group. This program reviews and modifies separation standards that will benefit safety and efficiency in the airspace.

In another initiative, work will begin on applying collision risk modeling methodology to the examination of terminal area structure design.

Products

Horizontal Separation Standards

- Reports on the feasibility of reduced horizontal separation in oceanic airspace.
- Reports on simulation and test results for reduced horizontal oceanic separations.
- Data packages for international coordination of horizontal oceanic separation standards.

Vertical Separation Standards

- Data analysis and operational tests and evaluation of reduced vertical separation.
- Recommendations for rulemaking on vertical separation standards.

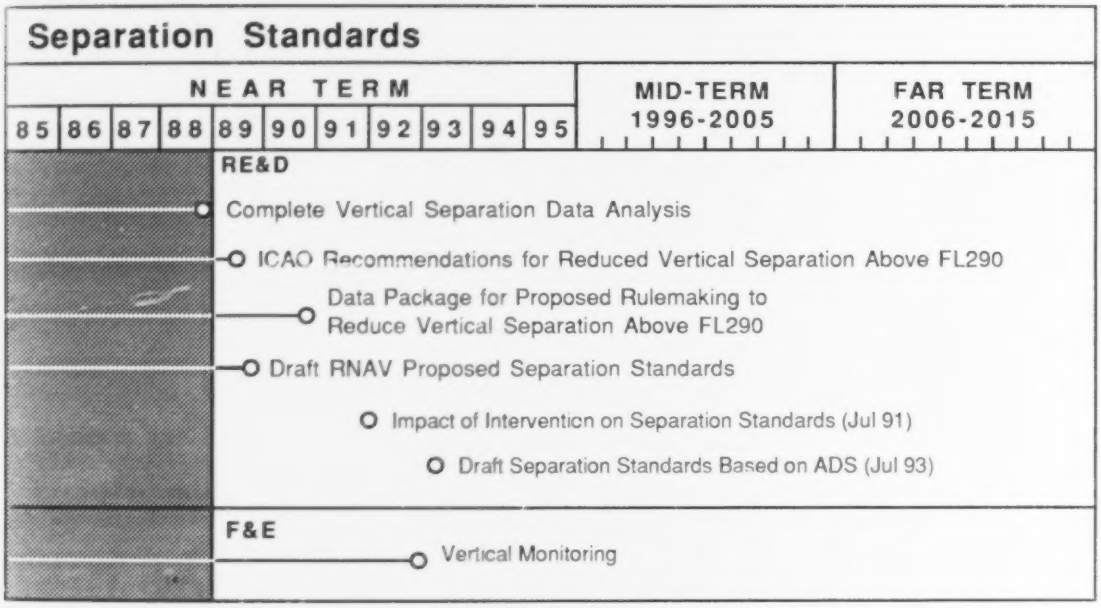
Recent Accomplishments

- Data collection and analysis performed to confirm proper operations on NOPAC composite routes.
- Data collection completed and data analysis begun for examination of the feasibility of reduced vertical separation above FL290.
- Analysis submitted on reduced safe longitudinal and lateral separation standard for the West Atlantic route system.

Related Projects/Activities

- ATC Applications of Automatic Dependent Surveillance -- Will provide technology for oceanic surveillance.
- Airport Capacity Improvements -- Will establish reduced separation standards for approaches to airports.
- Navigation Systems Development -- Provides new navigation performance to be evaluated.

Project 3.10


Separation Standards
NEAR TERM
85 86 87 88 89 90 91 92 93 94 95
MID-TERM
1996-2005
FAR TERM
2006-2015
RE&D
Complete Vertical Separation Data Analysis
ICAO Recommendations for Reduced Vertical Separation Above FL290
Data Package for Proposed Rulemaking to
Reduce Vertical Separation Above FL290
Draft RNAV Proposed Separation Standards
Impact of Intervention on Separation Standards (Jul 91)
Draft Separation Standards Based on ADS (Jul 93)
F&E
Vertical Monitoring

3.11 Wake-Vortex Avoidance and Forecasting

Responsible Division

ACD-200, Nelson Miller

Purpose

Improve current methods of avoiding hazardous wake vortices by revising general separation standards and developing procedures that more accurately reflect the actual hazard and its duration.

Approach

Examine classification of aircraft based on the strength of the wake vortex they generate. Collect wake-vortex data on new aircraft types. Collect new wake-vortex behavior data, including runway data and configurations. Examine operational alternatives in light of current wake-vortex knowledge and available technology. Develop wake-vortex computer models for aircraft classification and hazard avoidance.

Products

- Wake-vortex computer models for aircraft classification and hazard avoidance.
- Report on wake-vortex classification of aircraft.
- Wake-vortex hazard model.
- Wake-vortex hazard model software and report.
- Wake-vortex behavior data report.
- Report on advanced wake-vortex avoidance systems performance.

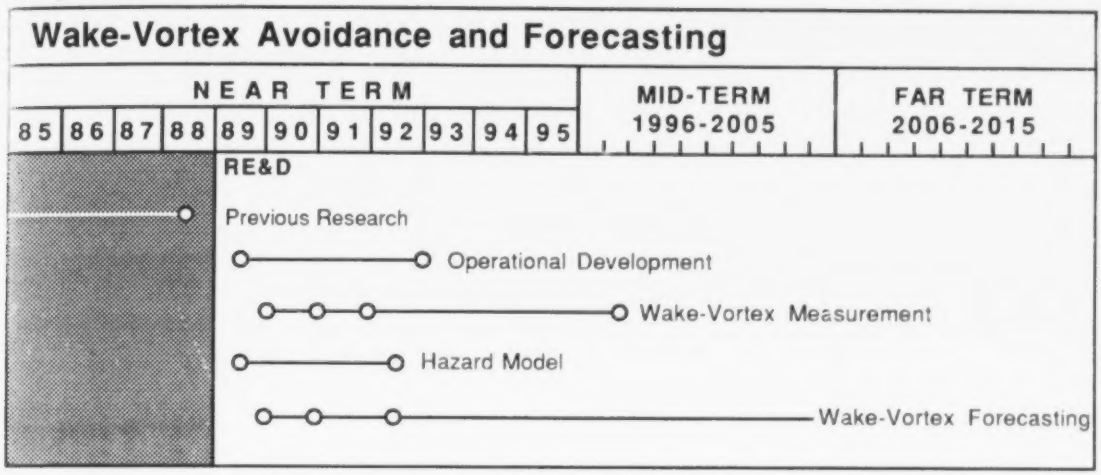
Recent Accomplishments

- Wake-vortex computer model for parallel runway approach evaluations developed.

Related Projects/Activities

- Wake-vortex forecasting -- Will provide accurate and timely wake-vortex forecasts.
- Precision Approach and Landing -- Will provide certified flexible MLS approaches.
- Wake-Vortex Avoidance Procedures (NASA-Ames) -- Will investigate different glide slope paths to a given runway and head-up display applications.

Project 3.11


Wake-Vortex Avoidance and Forecasting
NEAR TERM
85 86 87 88 89 90 91 92 93 94 95
MID-TERM
1996-2005
FAR TERM
2006-2015
RE&D
Previous Research
Operational Development
Wake-Vortex Measurement
Hazard Model
Wake-Vortex Forecasting

3.12 Rotorcraft Separation Standards

Responsible Division

ACD-200, Nelson Miller

Purpose

Validate current rotorcraft separation standards through analysis and testing of rotorcraft wakes and upset criteria. Recommend standards to improve the efficiency and safety of rotorcraft operations.

Approach

Collect data on the intensity and duration of rotorcraft wake and downwash flow fields. Develop model for rotorcraft hazards in wake-vortex encounters and validate the model with flight tests. Draft separation standards for rotorcraft operations.

Products

- Report on rotorcraft wake.
- Report on rotorcraft wake-vortex hazard model.
- Recommendations for improved rotorcraft separation standards and advisories.

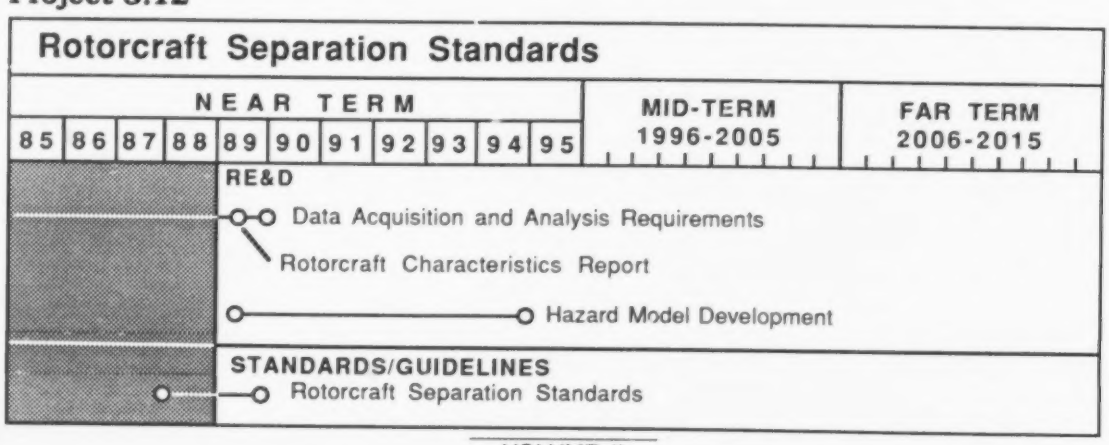
Recent Accomplishments

- Helicopter wake-velocity measurements report.

Related Projects/Activities

- Wake-Vortex Avoidance and Forecasting -- Classification criteria and hazard models will form a baseline for rotorcraft efforts.

Project 3.12



13 Fuel Optimization: Dynamic Ocean Track System (DOTS)

Responsible Division

AOR-200, David E. Winer

Purpose

Minimize fuel consumption, facilitate aircraft operations for both users and the ATC system, and improve ATC designs and procedures by developing a tool for flight planning and track loading.

Approach

An efficient algorithm for predicting the total energy consumption of aircraft operations on the ground and in flight has been developed. This algorithm predicts the in-flight energy consumption for any given aircraft flight performance, load characteristics, and operating conditions. It will be used to compute optimum fuel-efficient flight trajectories that will meet specific route, altitude, and time constraints imposed by the ATC system. These trajectories will be capable of being redefined dynamically, as required by changing winds, weather, and ATC constraints. This capability will be applicable to oceanic ATC to generate and control a fuel-efficient track system that can respond dynamically to wind, weather, and traffic load conditions.

In FY 1989, flight tests will be conducted in airspace controlled by the Oakland and Tokyo centers to verify the projected fuel burn and time savings for the scheduled air carriers. These flight tests will be completed in FY 1990. A prototype system will be operated in the Central Pacific for extended evaluation. Upon completion of the evaluation, the system is envisioned for widespread use over all oceanic areas.

Products

- Algorithms for minimum fuel path generation for an arbitrary set of position, altitude, velocity, and time constraints.
- Prototype hardware and software.
- Algorithms and operational guidelines for minimum fuel computations within the oceanic ATC system.
- Dynamic simulation model.
- Applications.

Recent Accomplishments

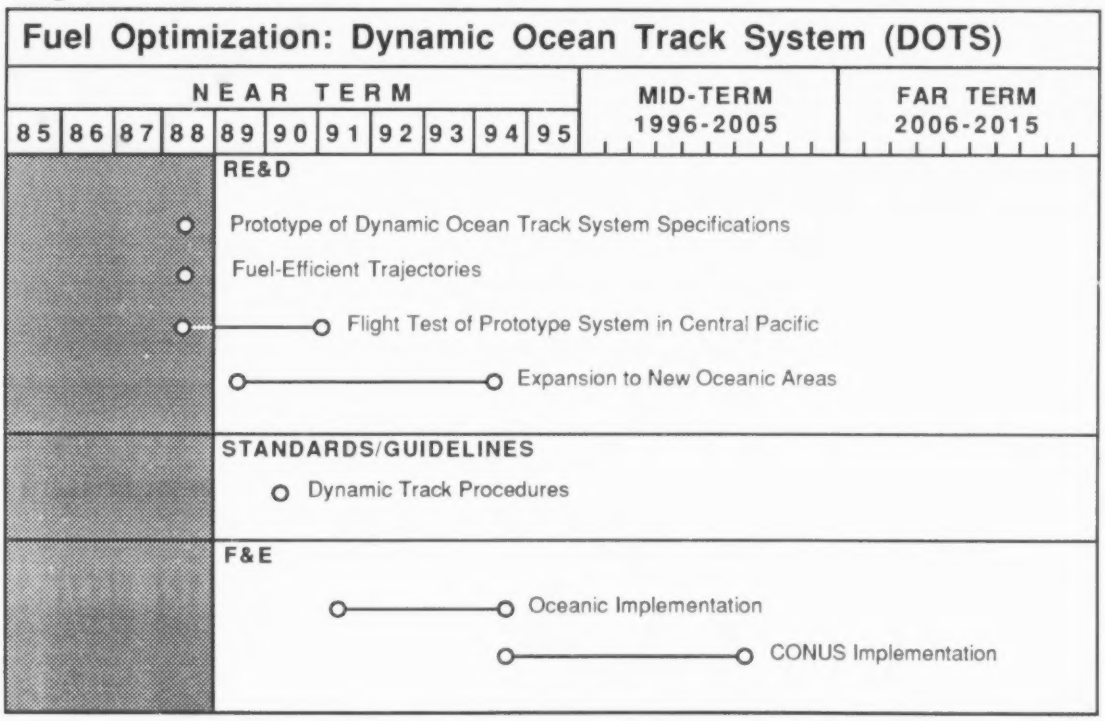
- Flight evaluation of the minimum fuel track and trajectory generation completed.
- Central Pacific track analysis and enhancement plan prepared.

- Hardware and software prototype at flight test stage.

Related Projects/Activities

- Separation Standards -- Will greatly increase efficiency of DOTS through enhanced track design flexibility.
- Advanced Traffic Management System (ATMS) -- May use the dynamic optimization technology to distribute real-time demand within system capacity.
- Automated En Route Air Traffic Control 3 (AERA 3) -- Dynamic conflict-free track loading is applicable to the contiguous United States (CONUS) as well as oceanic airspace.
- Terminal ATC Automation (TATCA) -- Optimization and display techniques used in DOTS are applicable to scheduling and spacing in the terminal area.

Project 3.13



14 Fuel Shortage Contingency Planning

esponsible Division

OR-200, David E. Winer

urpose

ssess the impact of a disruption in oil supply on air transportation and develop appropriate olicy options for the FAA's response to such an emergency.

Approach

In response to Section 271(a) of the Energy Emergency Preparedness Act of 1982, the FAA is developing an Aviation Energy Emergency Contingency Plan to deal with possible fuel shortages in aviation. In support of this plan, the following three specific activities will be pursued:

- Mathematical and statistical algorithms for a national oil shortage analysis model (NOSAM) are being researched and developed, and a database covering national fuel supply and consumption is being established. The model will quantify the effects of data in terms of national economic and aviation indicators. This information will then be used to develop policy options and to determine the benefits or impacts of those options. In order to make objective decisions, the model will consider such options as regulation of private stock, allocation of supplies, drawdown of the strategic petroleum reserve, implementation of emergency ATC procedures, imposition of slot allocation, and use of flight plan optimization.
- Procedures for maintaining essential air service during an aviation fuel shortage are being identified. These procedures will be evaluated during the development of the policy options associated with NOSAM to ensure the maintenance of maximum possible levels of air service.
- NOSAM will be tested thoroughly by imposing hypothetical oil supply disruption scenarios on the aviation system. These studies will be used to identify areas of needed improvement, and the model will then be modified and retested.

Products

- Microcomputer software package.

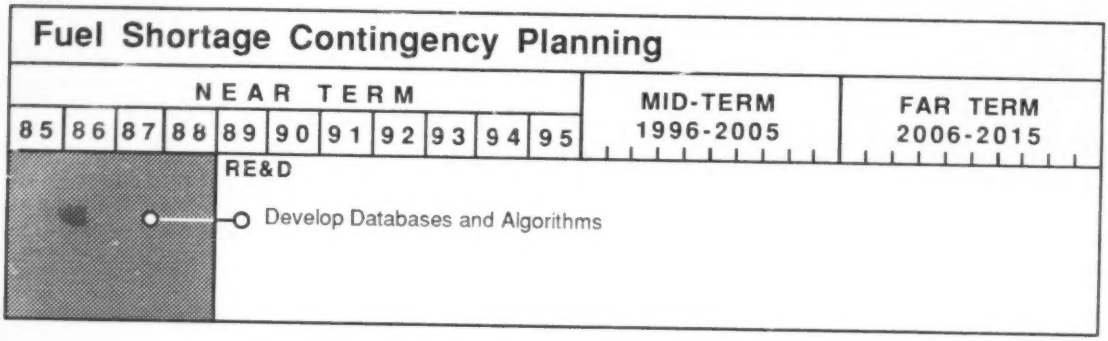
Recent Accomplishments

This work is being planned for restart in FY 1990.

Related Projects/Activities

None.

Project 3.14



.15 Advanced Automation System (AAS)

esponsible Division

AP-1, Leland F. Page

urpose

rovide management support for AAS acquisition and implementation. The AAS will provide new automation system that includes the controller workstations, computer software, and rocessors necessary to handle projected air traffic loads in the 1990s and beyond.

pproach

A disciplined approach to project management is required to successfully implement a large and complex system such as the AAS. Management activities provided by this project include program reviews, administrative management, program analysis and control, development and administration of budgets and fiscal programs, planning and scheduling review and approval of procurement documents, development of management information systems, design trade-off studies, requirements analysis and tracking, development of technical procurement packages, proposal evaluation, technical contract management, design review, data management, engineering testing and evaluation, and implementation activities.

Products

No new RE&D products.

Recent Accomplishments

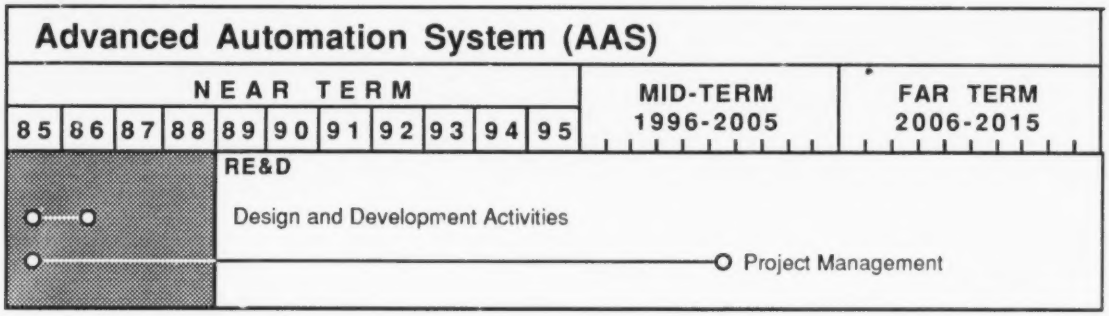
- AAS acquisition contract awarded.

Related Projects/Activities

- ATC host computer system project, now completed, is the first transitional step of the advanced automation program.
- AAS en route software will be modified to include AERA 1, AREA 2, and AREA 3 functions.
- The CWP, data-link processor, Mode S, traffic management system, and remote maintenance monitoring systems all interface with the AAS.
- Voice Switching and Control System Development is a new communications system that must be implemented in order for the initial sector-suite system to function.

- National Airspace Data Interchange Network and radar microwave link will provide required switching and transmission network services for the AAS.
- AAS has the hardware and software necessary for consolidation of en route and terminal functions into ACFs.

Project 3.15



16 System Concept Definition

esponsible Division

DS-100, Clyde Miller

urpose

evelop, maintain, and validate a coherent and comprehensive vision for aviation system volution. Ensure that all system resources are identified and that gaps or redundancies are voided.

Approach

Develop an integrated vision of the evolution of the national aviation system based on near-term improvement plans (in particular, the NAS F&E Plan), assessments of improvements that will be required in the mid-term, and the future state of the aviation system as defined by the Future System Definition project. Assess mid-term improvements based on analyses of system performance and foreseen demand, estimates of the extent to which currently planned improvements will offset existing performance shortfalls, and analyses of technical and operational opportunities for improving performance, including cost-benefit aspects.

Develop an integrated ATC automation concept. The integrated concept will extend from the airport surface to oceanic airspace and will include traffic management functions. Develop an Advanced Concept Laboratory as a means for validating this automation concept using scenarios that will permit air traffic controllers to evaluate the operational feasibility of proposed techniques.

Identify, develop, and evaluate advanced concepts for providing new or existing capabilities more effectively. In particular, a synthetic vision capability based on airborne millimeter radar technology and capable of providing high-resolution images of the airport environment will be explored. This concept has the potential to significantly reduce costs while increasing the reliability of approach and landing operations in instrument meteorological conditions.

Products

- Integrated ATC automation concept.
- Advanced Concepts Laboratory.
- Synthetic vision concept.

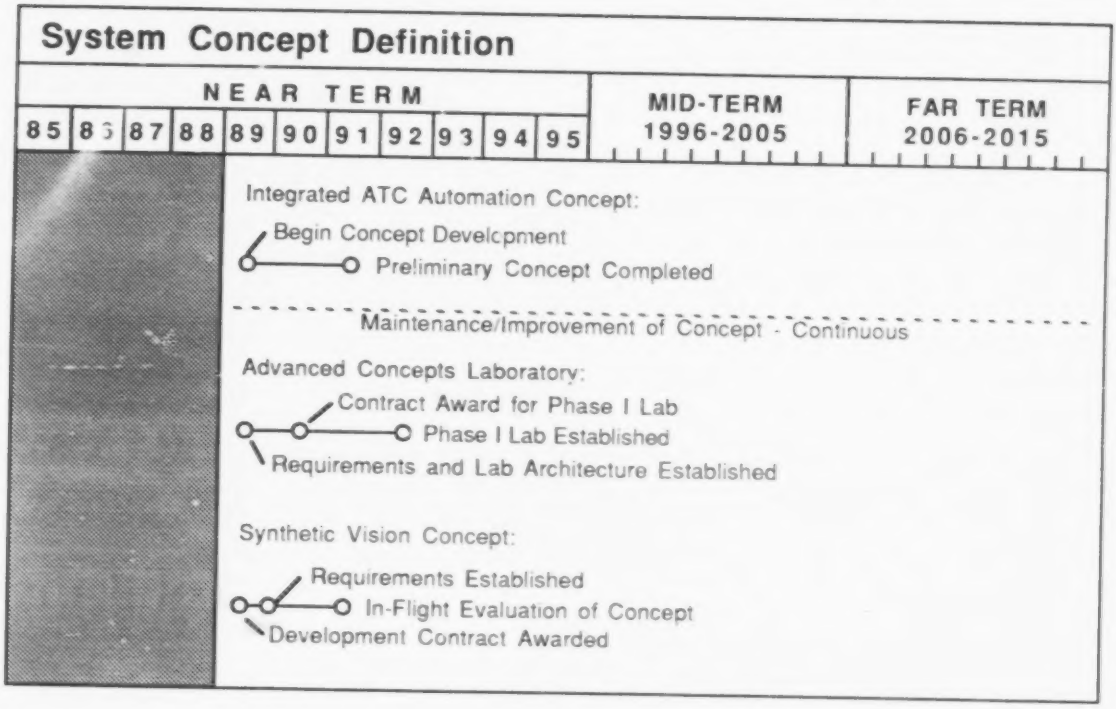
Recent Accomplishments

None - new start.

Related Projects/Activities

- Future System Definition.

Project 3.16



4. Communications

Communications users include not only pilots and controllers, but also computer systems, surveillance equipment, weather sensors, and air-ground equipment. These users are linked together today with the largest civil communications system in the federal government. The projects in this technical area primarily support the major mission area of efficiency, along with elements of the safety and capacity missions. Projects included are:

Communications

4.1	Future Communications Requirements and Architecture
4.2	Network Management and Control Equipment (NMCE)
4.3	Voice Switching and Control System Development (VSCS)
4.4	National Airspace Data Interchange Network (NADIN)
4.5	Aeronautical Data-Link Communications Applications

Interfacility communications systems provide communications between FAA facilities, including major manned facilities such as air route traffic control centers, airport traffic control towers, and radar sites; ground-to-air radio sites; and other smaller remote facilities.

The current interfacility system has evolved piece by piece as requirements dictated. In the past, circuit costs were low, and the ability to provide services was generally limited to public utility communications companies. Over the years, however, common carrier telecommunications rates have escalated and are expected to continue to do so, although competition has recently emerged in almost all telecommunications areas. Opportunities are now available for the FAA to take a systems approach to its interfacility communication needs and to develop a network which will provide greater reliability through alternate routing capabilities, flexibility, and growth potential, while constraining operating costs.

The National Airspace System (NAS)interfacility communications system (NICS) will be established to combine and integrate communications functions into one network. NICS will provide voice and data communications interconnectivity between facilities and sites within the aviation system, along with intrafacility communications and access to other external systems (e.g., the automatic voice switching network). NICS will support other system elements by providing voice and data services in three functional areas: transmission, switching, and monitor and control. This new approach will result in improved and expanded user services, while controlling costs. In the long term, facility consolidation and new services, such as Mode S data link and automated en route air traffic control (AERA), will impose increasing interfacility requirements. The comprehensive network will accommodate these requirements through use of satellites and other appropriate technologies.

The ability of ground and airborne systems to exchange data without imposing added workload on pilots, controllers, or specialists will be a key element of a future air traffic control (ATC) environment that will operate more efficiently with higher productivity and enhanced safety. The procurement of the Mode S system, with its integral, highly reliable data communications

capability, is a necessary step toward achieving this end. However, the link itself is only an element of what must become an expansive communications architecture. Standards and guidelines for data-processing avionics must be developed that allow for the sharing of cockpit input and output devices among the independent radio frequency links that will exist -- Mode S, high frequency, very high frequency, and satellite. An architecture is needed that will allow for evolutionary changes to air-ground data communications and provide the capability to extend ATC and flight services as air-ground data-link availability increases. At the same time, an expandable and flexible architecture of ground system elements must be maintained to accommodate the development of new air-ground data communications applications and the addition of new information origins and destinations.

This new communications architecture is being implemented through a set of near-term projects described in the NAS Facilities and Equipment (F&E) Plan. There are, however, also certain unique requirements that necessitate research and development efforts for these elements. The FAA must maintain a posture that allows the integration of cost-effective communications technologies into the ATC system.

1 Future Communications Requirements and Architecture

Responsible Division

AAS-500, Norm Fugisaki

Purpose

Develop a framework for FAA communications systems that provides the most cost-effective use of current and emerging technologies and the capability for meeting communications needs into the 21st century. The project will define basic system architecture and requirements.

Approach

Determine the feasibility, cost, and impact of a digital microwave system, digital radio control equipment, and a low-density, digital, drop-and-insert capability. Digital switching architectures and a low-density user-access network will be examined. If feasible and cost-effective, these technologies will be implemented in the mid-1990s.

Products

- Digital network feasibility reports.
- All-digital interfacility network architecture.
- Integrated voice/data intrafacility communications architecture.
- Digital communications protocol standard for the national aviation system.

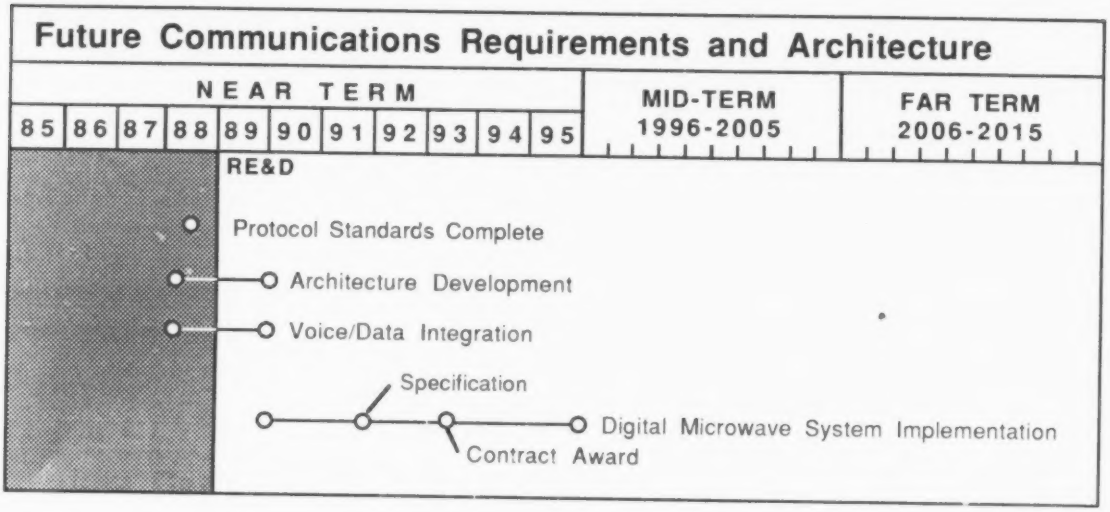
Recent Accomplishments

- FAA microwave network plan developed.
- Standard for the national aviation system protocols selected.

Related Projects/Activities

- Radio control equipment -- Will modernize existing radio tone control equipment for control and remote maintenance monitoring of facilities.
- Radar microwave link (RML) replacement and expansion -- Will provide a network of microwave radio communications links for voice and data.
- Voice Switching and Control System Development -- Will integrate interfacility voice and data transmissions.
- Future Satellite C/N/S Systems Applications -- Will investigate satellite applications to interfacility communications.

Project 4.1


Future Communications Requirements and Architecture
NEAR TERM
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MID-TERM
1996-2005
FAR TERM
2006-2015
RE&D
Protocol Standards Complete
Architecture Development
Voice/Data Integration
Specification
Digital Microwave System Implementation
Contract Award

2 Network Management and Control Equipment (NMCE)

esponsible Division

SE-200, Joseph DeMeo

urpose

efine communications management and control functions and develop supporting rocedures and architectures for national, regional, and area control facility (ACF) levels of ontrol.

pproach

The FAA has embarked on a significant effort to modernize the ATC communications system, which comprises transmission and switching subsystems. Management and control functions and capabilities must be modified or enhanced to accommodate the changes needed to meet the performance and availability requirements of the communications systems for the national aviation system.

Specific activities will include definition of the NMCE system and functions that will allow the FAA to isolate faults and restore service in a timely manner, set parameters and thresholds, monitor traffic, collect data, and perform network planning. A prototype NMCE workstation for evaluating man-machine interfaces and automation techniques for network management functions will be developed. The NMCE specification will include network management automation requirements and performance criteria. Phase I will provide basic manual and semiautomatic switching, control, and restoration capabilities. Phase II will provide a fully integrated system with automatic control, switching, and other enhancing capabilities.

Products

- Definition of communications management and control functions.
- Network management control (NMC) operational concept.
- NMCE architecture.
- NMCE specification.
- NMCE workstation.
- Network management automation requirements.
- NMCE man-machine graphics design requirements.
- NMCE performance requirements.

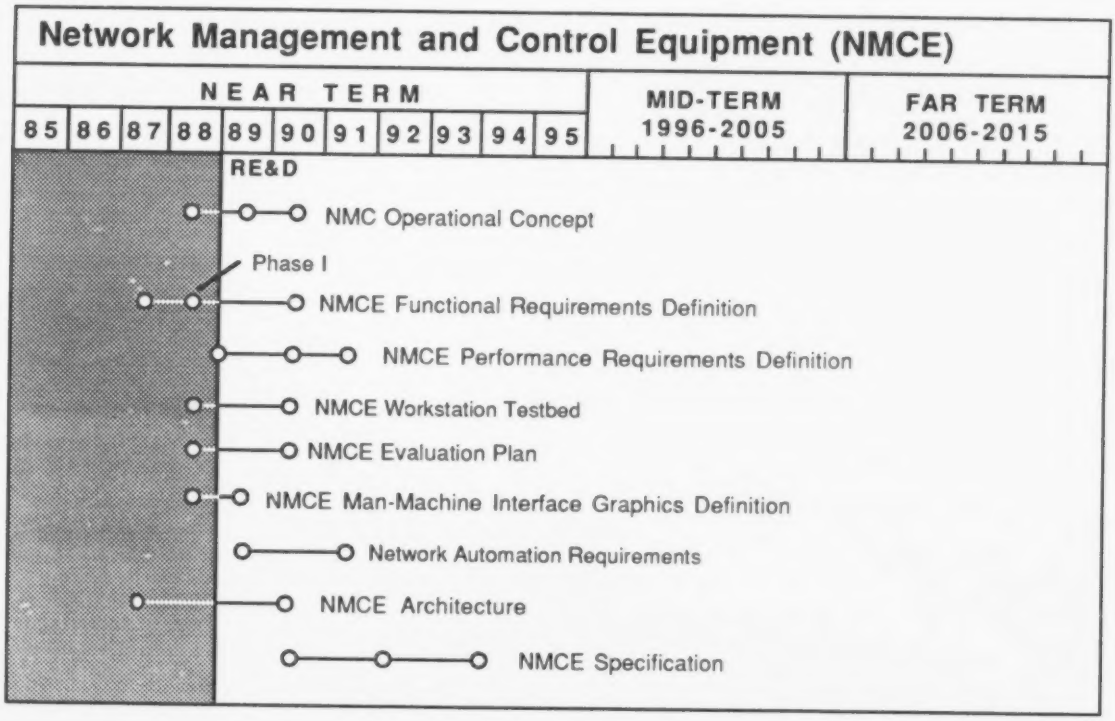
Recent Accomplishments

- Developed NMCE Phase I functional requirements.
- Defined and developed initial prototype NMCE workstation.

Related Projects/Activities

- Radar microwave link (RML) replacement and expansion (NAS F&E Plan) -- Will provide a network of microwave radio communications links for voice and data.
- National Airspace Data Interchange Network (NADIN) IA and II -- Will provide expanded data-switching capability and network monitoring functions.
- Voice switching and control system (VSCS), integrated communications switching system, and tower communications system -- Will support inter- and intra-facility voice communications.

Project 4.2



3 Voice Switching and Control System Development (VSCS)

esponsible Division

AP-400, H. Lee Tucker

urpose

ovide management support to develop connectivity and control functions for ATC, tercom, interphone, and air-ground voice communications systems.

pproach

Provide management support to:

- Develop two competing prototype systems using off-the-shelf technology - FY 1987 to 1989.
- Acceptance test and design competition - FY 1989.
- Select production design - FY 1989.
- Production-critical design review - FY 1990.
- Update design - FY 1990.
- Commit to full production - FY 1990.

Products

No new RE&D products.

Recent Accomplishments

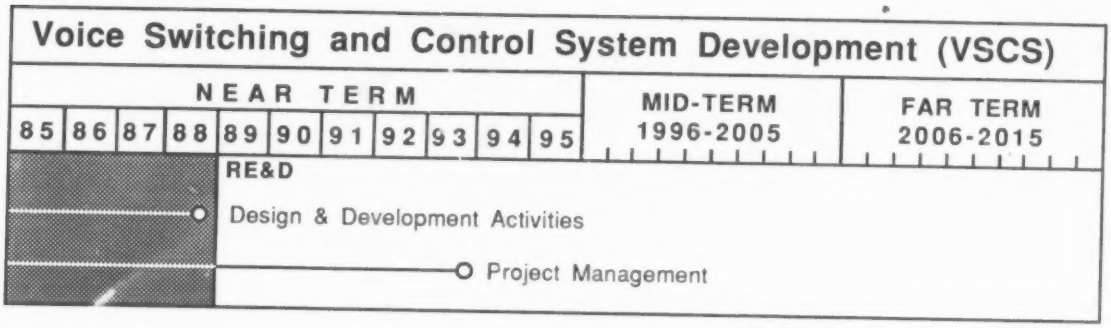
- Prototype critical design review.

Related Projects/Activities

- VSCS must be available and installed prior to initial sector-suite implementation.
- Radio control equipment performs the radio channel signaling and control functions to support ground-air voice communications.
- Multichannel voice recorders record all voice communication between air traffic controllers and pilots.

- The Advanced Automation System (AAS) interfaces with the VSCS for configuration status and control data.
- NICS provides required interfacility communications.
- Radar microwave link (RML) replacement and expansion provides required transmission network.

Project 4.3



4 National Airspace Data Interchange Network (NADIN)

esponsible Division

PS-500, Norm Fugisaki

urpose

nalyze, design, and specify enhancements to NADIN II that will meet the data transfer equirements of the major FAA project functions and facilities in the NAS F&E Plan. As it volves, NADIN II will provide a cost-effective and integrated common-user data transfer ystem. The resulting communications system will cost significantly less than alternative etwork solutions and will substantially reduce the number of dedicated circuits and their ssociated costs.

Approach

NADIN II system design is based on data transmission requirements of new systems and consolidation of present systems. This communications utility will be coordinated with other FAA communications initiatives to provide required trucking and transmission facilities. NADIN II development involves a two-phase approach, resulting in a single specification that will satisfy both Phase 1 and 2 requirements.

Phase 1 will provide packet-switching nodes with virtual circuit and alternate routing capability, centralized network control and monitoring, and additional trunking. Phase 2 will provide the capability for system enhancements, including additional system capacity, connectivity, and interfaces. The standardization of access interfaces and exchange protocols will be specified to ensure future flexibility for system evolution. NADIN II will provide quick-response, interactive data transfer and efficient file and database transfer capabilities.

Evolution of the ATC system to provide the capability for a standard interface to NADIN II will require the development of new network management capabilities. A protocol conversion capability will allow existing FAA terminal equipment to operate with the standard NADIN II interface. In addition, the capability to interface NADIN II to existing message-switching systems will necessitate the development of a gateway capability between networks.

During FY 1988, studies were performed to assess the overall communications requirements of the AAS in the 1990s and to generate the technical documentation necessary to determine the maximum scope of the required NADIN II Phase 2 expansion. In FY 1989, funds will be used to further analyze the requirements of the AAS to determine the exact expansion required. The F&E-funded expansion will be implemented according to these studies. In FY 1990, these activities will continue.

Products

- Phase II expansion requirements.
- NADIN II functional verification.

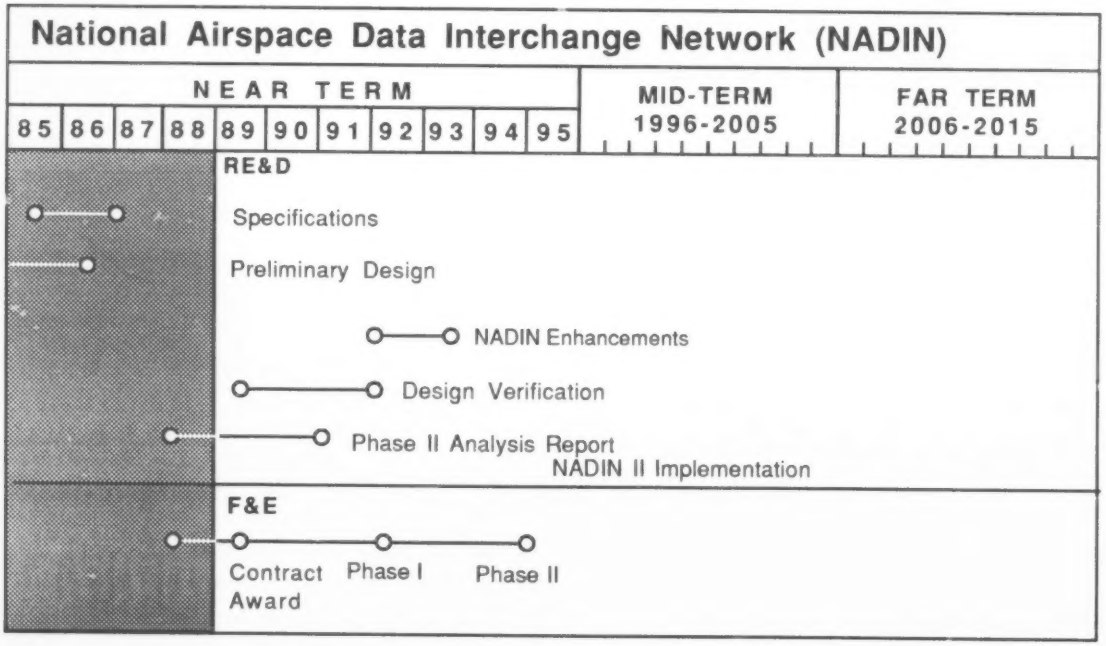
Recent Accomplishments

- Specifications developed and approved.
- Interface documents developed and baselined.

Related Projects/Activities

- Future needs for ACFs and the AAS will be met by these NADIN enhancements.
- NADIN will satisfy remote maintenance monitoring system data transmission requirements.
- NADIN will satisfy weather data distribution requirements determined for the Central Weather Processor (CWP).

Project 4.4



5 Aeronautical Data-Link Communications Applications

esponsible Division

SA-100, Robert Valone

urpose

)evelop data-link applications needed to provide users with improved air-ground data ommunications services to achieve NAS F&E Plan goals of higher productivity, increased fficiency, and enhanced safety. This effort will support the creation of the future ATC nvironment.

Provide the technical development needed to implement the Mode S data-link system as an air-ground data communications element within the national aviation system.

Approach

Implement air-ground data communications applications via Mode S data link to meet the following national aviation system objectives: (1) establish a flexible air-ground data communications system to provide communications between national aviation system elements and properly equipped aircraft and (2) develop useful applications for the data communications system. To support these efforts, a Mode S data-link engineering testbed is being developed.

Develop the architecture of the air-ground communications system to conform to the separation of functions specified by the open systems interconnection (OSI) reference model. This will allow applications development independent of the air-ground links used for communications. Protocols will allow the use of multiple air-ground data links. The testbed will help verify the correctness of communications protocols. Protocols to be tested will include both Mode S data link and end-to-end communications functions not specific to Mode S. The testbed will also test the operability of multiple air-ground data links. Developing and evaluating these communications protocols will further the establishment of guidelines and standards for related avionics. This, in turn, will lead to a wider implementation of Mode S data link.

Activities include developing, testing, and validating operational concepts for several data-link applications, as well as defining message flows, content, and format for each application. The project also addresses message-processing algorithms and detail-specific human interfaces.

Initial air-ground data communications applications to be evaluated with the testbed are pilot- or controller-initiated services. Evaluation will focus on fitting applications to pilot or controller work environments. Future services will take advantage of automation capabilities, both on the ground and in aircraft, to anticipate a need for information and provide that information automatically. Applications will benefit aircraft operating under both visual flight rules (VFR) and instrument flight rules (IFR). The testbed facility will house ground-based computers and will also contain aircraft with avionics and cockpit input/output devices of varying levels of capability.

Cost-benefit studies of proposed air-ground data communications applications will be conducted to determine the priority of Mode S services and the order of their implementation. Guidelines for service implementation will be developed that will provide OSI detail and ensure the interoperability of multiple links. Communications protocols and message-coding standards for text; graphic; and bit-oriented, air-ground data-link communications will be developed. Interfaces between Mode S and all NAS F&E Plan projects providing or using the air-ground data link will be defined. Technical guidance will be provided as appropriate.

Applications to be examined include:

- Air-ground data exchanges (some totally automated) necessary to allow real-time flight plan processing on the aircraft and to communicate time-based clearances.
- Provision of automatic traffic, terrain, and airspace information.
- Automatic generation of sequencing and spacing clearances.
- Surface traffic management aids.
- Automated airport services at both manned and unmanned facilities.
- Automated weather update information and automated terminal information service for equipped VFR and IFR aircraft.
- Automated aircraft weather-reporting systems.
- Automated on-screen display of hazardous weather conditions in the cockpit.
- VFR flight following and search and rescue service.
- Weather graphics products for low-cost avionics.
- Downloading of aircraft control surface information for improved Mode S tracking.

Products

- Development systems -- Mode S data-link engineering testbed and other engineering tools; Mode S data-link avionics testbed (processors and input/output devices); and demonstration, testing, and user evaluation of applications.
- Software -- Application-independent communications protocols and message-coding algorithms, interfaces between Mode S and NAS F&E Plan projects that provide or use the air-ground data link, and applications and interface software ultimately needed to implement feasible and cost-beneficial services.

- Technical guidance data -- Data-link national aviation system standard, data for the Radio Technical Commission for Aeronautics (RTCA) process that is developing minimum operational performance standards (MOPS), data for the development of International Civil Aviation Organization standards and recommended practices, and data-link interoperability guidelines.
- Requirements and analyses -- Architectural and operational requirements for Mode S data link interface with the AAS, CWP, and weather communications processor; correlation of graphic data-link weather presentation with actual weather, as observed by the pilot, to permit product improvement; user and FAA cost-benefit studies of feasible data-link applications to determine service priority and implementation order; and operational concepts for each application.

Recent Accomplishments

- A draft MOPS for the Mode S data-link processor, developed by the RTCA. MOPS uses the OSI reference model developed by the International Organization for Standardization. Implementing this model permits use of both data links (e.g., Mode S and satellite) and input/output devices on board an aircraft.
- Testbeds have been established at the FAA Technical Center, Lincoln Laboratory, and MITRE Corporation to develop and validate data-link applications in cooperation with the FAA and user community.
- Several ATC services have been identified for early implementation in the national aviation system. These services were chosen to provide early benefits and to encourage equipage of Mode S data-link avionics.
- Over the past year, representatives from the data-link applications program have visited and briefed a number of aviation organizations, avionics manufacturers, and airframe manufacturers to update them on the FAA's Mode S data-link program. These briefings encourage users to support the development of data-link applications and prepare for the implementation of the Mode S data link.

Related Projects/Activities

- Mode S (NAS F&E Plan) -- Provides two-way radio frequency data link to aircraft equipped with the Mode S transponder.
- Aeronautical data-link processor (NAS F&E Plan) -- Provides message formatting and sensor routing for all applications.
- Advanced Automation System (NAS F&E Plan) -- Provides data-link processing for ATC services.
- NADIN II -- Provides communications paths between the Mode S sensors and ground system elements.

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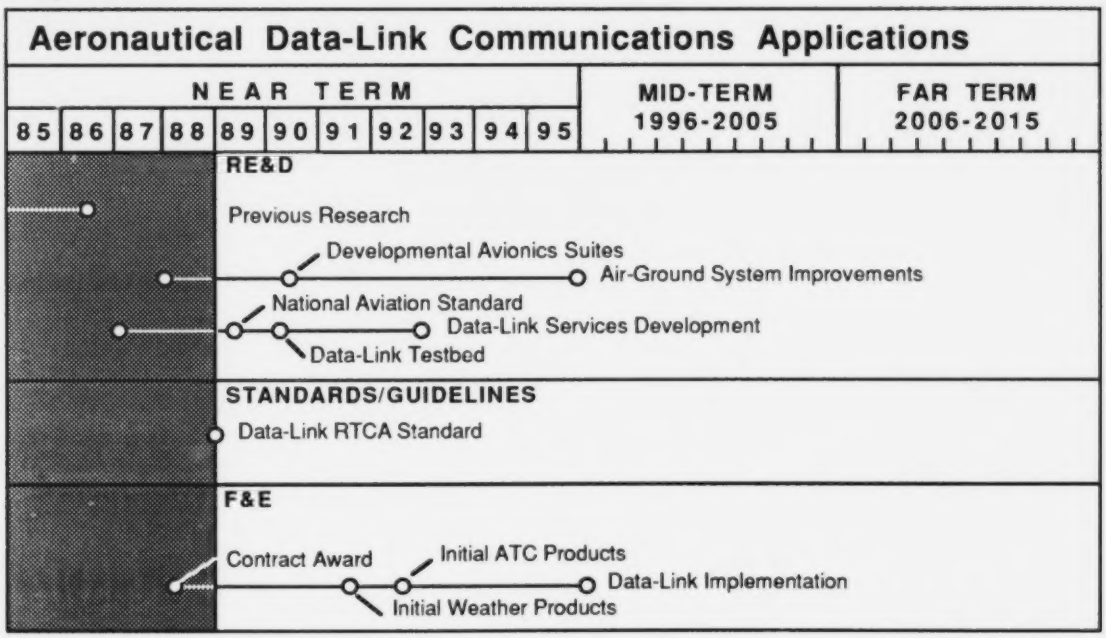
- Automated En Route Air Traffic Control 3 (AERA 3) -- Provides the algorithms required to generate the air-ground data exchanges needed to implement the airspace management concept.
- Flight Service Automation System, Central Weather Processor, the Weather Radar Program, and Automated Weather Observing System (NAS F&E Plan) -- Will provide data for transmission via Mode S data link.
- Airport surface surveillance -- Provides Mode S data communications with aircraft on the airport surface.
- ATC Applications of Automatic Dependent Surveillance -- Will provide technology for oceanic surveillance.
- Oceanic Display and Planning System (NAS F&E Plan) -- Will provide a baseline for ATC controller displays and aids for oceanic ATC.
- Human Performance Assessment and Improvement.
- Information Transfer and Management.

Project 4.5



5. Navigation and Landing

The FAA has the responsibility for developing and implementing radionavigation systems to meet the need for safe and efficient navigation and control of all civil (and a significant portion of military) aviation. The Federal Radionavigation Plan (FRP), jointly developed by the Department of Defense (DoD) and the Department of Transportation (DOT), sets forth an approach to the implementation and operation of radionavigation systems that ensures the efficient use of resources and the full protection of national interests. Three major RE&D projects support the FAA navigation and landing systems responsibilities:

Navigation and Landing

5.1	Improvements to Navigation Systems
5.2	Precision Approach and Landing
5.3	Navigation Systems Development

These projects respond to the recommended policies and plans set forth in the FRP and to the expressed needs of airspace users. However, as user needs continue to evolve and demands on the aviation system grow, alternative system concepts and technologies will need to be examined. For example, helicopter operators require low-altitude, high-accuracy navigation coverage in urban areas where LORAN C may not be adequate. Effective integration of area navigation capability is needed so that users can realize the full extent of fuel savings and other benefits made possible by that concept. Through a joint DoD/DOT policy statement, agreement has been reached to pursue approval of the global positioning system (GPS) as a supplemental en route navigation system. Further evaluation and development of GPS will be conducted with the goal of certifying it as a "sole-means" navigation system, and an integrated GPS-GLONASS avionics will be investigated to determine if such a configuration can be used as a worldwide sole-means system. The integration of LORAN C and GPS in avionics will also be examined to determine whether this combination can serve as a sole means of navigation in the aviation system.

With regard to precision approach and landing services, operation-specific standards and procedures need to be developed for conventional, short takeoff and landing, and vertical takeoff and landing aircraft to permit use of the wide-angle coverage capabilities and growth features (e.g., 360-degree azimuth function) of the microwave landing system (MLS). Other planned MLS support activities include the definition of lighting system requirements and the development of appropriate International Civil Aviation Organization (ICAO) standards and guidance material for MLS installations.

The results of these activities will be examined and used as input to the biennial FRP update. This will serve to refine the recommendations for the mix of systems needed to satisfy civil and military aviation requirements.

5.1 Improvements to Navigation Systems

Responsible Division

ASA-100, Robert Valone

Purpose

Expand the utility, improve the performance, and increase the efficiency of navigation systems currently operated and maintained by the FAA. Aid in the orderly integration of evolving airborne navigation technology into the national aviation system.

Approach

Modernize and sustain engineering of ground-based navigational aids to reduce operating costs and improve performance. Available technology will be identified, and its applicability to navigational aids that would improve performance or meet new requirements will be assessed (e.g., improving the very high frequency omnidirectional range (VOR) antenna system to reduce sensitivity to the site environment). The technical feasibility and potential benefit of adding functions within the VOR, distance measuring equipment (DME), or nondirectional beacon (NDB) radio frequency spectra, without degradation of existing service, will be assessed (e.g., the use of spread-spectrum techniques to transmit navigation data to aircraft).

Potential enhancements will be evaluated in simulated operations. Validation of these enhancements will be accomplished through use of prototype hardware and software developed for limited operational evaluations (e.g., the application of one-way ranging techniques to DME).

Based on the results of the tests and evaluations, guidelines and equipment specifications will be developed. For example, FAA approval of the GPS for civil use, either as a supplemental or sole-means air navigation system, requires that the system satisfy all applicable requirements. Relevant GPS performance issues include integrity and coverage reliability. GPS will be used in progressively more demanding applications, ranging from en route navigation to nonprecision approach guidance. This process will include tests and evaluations involving the available satellite constellation, laboratory simulations, and analytical studies. Flight tests will include representative actual or simulated environments, using available GPS receivers.

Performance standards and certification guidance will be developed for users' avionics equipment and integrity-monitoring facilities. Documents will include national aviation standards, minimum operational performance standards for avionics, and avionics certification guidance.

As a supplemental means for navigation, GPS should have little impact on existing systems, standards, and operational procedures. Adopting GPS as a sole-means navigation system, however, would require more stringent integrity and coverage reliability.

his project will investigate enhanced navigation performance through systems integration. In articular, the integration of LORAN C and GPS in avionics will be examined to quantify ossible performance. Currently, GPS and LORAN C are both supplemental aids: an pproved system must be available on the aircraft if either is used in instrument conditions. hrough integration, it may be possible to develop an airborne system that can be approved s a sole means of navigation.

lethods for managing airborne navigation databases to ensure that aircraft and air traffic ontrollers are using common reference information will also be investigated.

Products

- Reports on the technical, operational, and economic feasibility of adding new functions to existing navigational aids.
- Evaluation of prototype navigation system improvements.
- Specifications for improvements to ground-based systems.
- Revised standards for performance and design of systems.
- A report on airborne database management methods.
- A report on the use of GPS as a sole-means radionavigation system.
- Specifications of recommended technical and operational design characteristics for user equipment, ground control and monitoring system, and other appropriate elements, as a function of the following operational applications:
  - En route navigation -- supplemental and sole means.
  - Nonprecision approach.
- Reports presenting cost-benefit assessments and recommended guidelines for integrating GPS into the national aviation system as a function of operational applications.
- Report to the Congress on integrated GPS and LORAN C navigation.

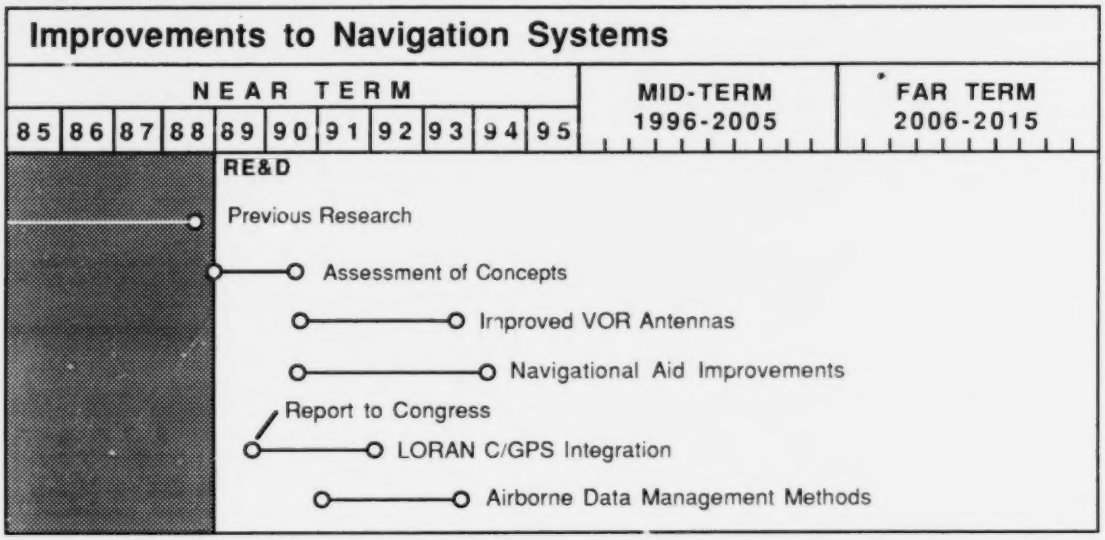
Recent Accomplishments

- LORAN C ground station equipment procured to expand coverage of the 48 contiguous states by having the U.S. Coast Guard install four new midcontinent stations.
- LORAN C monitors produced to support LORAN C nonprecision approaches.
- "Sole-means" requirements established for accuracy, coverage, and integrity.
- National Aviation Standard for NDB.

Related Projects/Activities

- Navigation Systems Development -- Will incorporate enhancements to navigation systems into the FRP.

Project 5.1



2 Precision Approach and Landing

Responsible Division

ADS-200, William F. White

Purpose

Develop operational procedures and criteria for advanced MLS configurations and special applications.

The MLS has been adopted by the ICAO as the international standard approach and landing system to replace the instrument landing system (ILS). The azimuth and elevation stations and associated precision distance measuring equipment (DME/P) will support a variety of curved and segmented area navigation (RNAV) approach paths.

Approach

Research and development for MLS will continue to support and enhance MLS operations in the National Airspace System (NAS).

- Analyze current autoland systems to determine the feasibility of shorter final approach length with modified capture laws using MLS curved intercepts.
- Develop MLS RNAV capability in Phase II training simulator.
- Study aircraft/ATC integration of advanced MLS procedures using interactive cockpit/ATC simulators.

Products

- Working papers for all-weather operations panel of ICAO.
- Recommendations for back azimuth display sensitivity and switching logic.

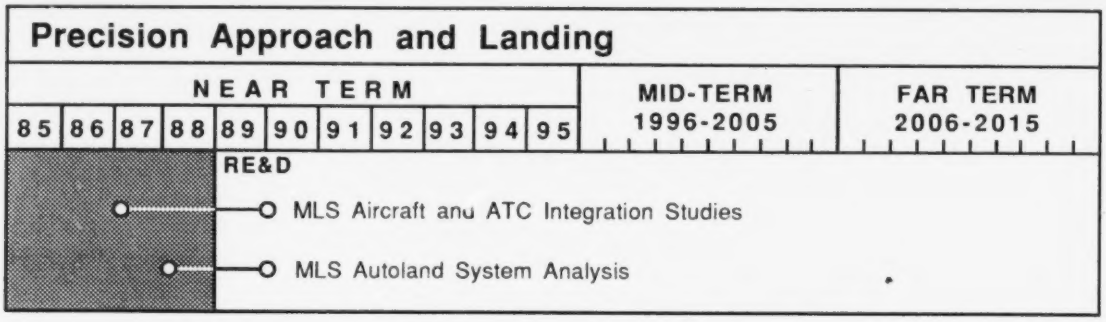
Recent Accomplishments

- Optimum sensitivity value determined for missed approach and departure.
- Front-to-back azimuth transition method determined.

Related Projects/Activities

- Integrated studies to provide data on advanced MLS applications from the ATC standpoint. Selected airports are modeled, with proposed MLS approaches and departures studied using controllers familiar with existing procedures at these locations.

Project 5.2


Precision Approach and Landing
NEAR TERM
85 86 87 88 89 90 91 92 93 94 95
MID-TERM
1996-2005
FAR TERM
2006-2015
RE&D
MLS Aircraft and ATC Integration Studies
MLS Autoland System Analysis

.3 Navigation Systems Development

esponsible Division

DS-100, Clyde Miller

urpose

dentify and evaluate emerging technologies and new concepts for application in the evolution f navigation services to satisfy future requirements. This project supports the biennial revision f the FRP and provides the FAA input to the DOT/DoD Navigation Working Group. Possible uture navigation systems will be examined as either extensions of or alternatives to existing planned navigation systems, with the goal of satisfying projected user requirements.

Approach

Future navigation systems will be subjected to a total system analysis that addresses safety, economic performance, and operational and technical issues. At a minimum, these future systems should:

- Meet the service needs of the civil aviation community.
- Be responsive to changing operational and technological environments.
- Accommodate a necessary degree of standardization and interoperability for both domestic and foreign operations.
- Meet the required level of service in a cost-effective manner.

Algorithms and potential systems will be developed and applied in laboratory simulations to test the effectiveness of proposed concepts (e.g., geostationary satellite system one-way ranging systems). The relative merits and deficiencies of different systems will be measured against requirements. Based on results, technical and functional design specifications will be developed for the recommended system.

Supplemental studies and analyses will be performed as necessary to support more fully the FAA input to the DOT/DoD Navigation Working Group. This input will refine recommendations published in the FRP on the mix of systems needed to satisfy civil aviation requirements.

The principal new navigation system that will benefit civil aviation is the GPS. Additional investigations will continue through FY 1990 relating to self-contained integrity techniques now that the DoD has requested approval of a 24-satellite constellation. The development of the ground monitoring system suitable for nonprecision approaches will also be completed in this time frame.

One new concept being explored is the integration of GPS and the USSR's GLONASS satellite navigation system to provide a sole-means worldwide radionavigation system. Parallel to these efforts, the 1990 edition of the FRP will be published.

Products

- Biennial publication of the FRP.
- Specified technical and operational design characteristics of the recommended system.

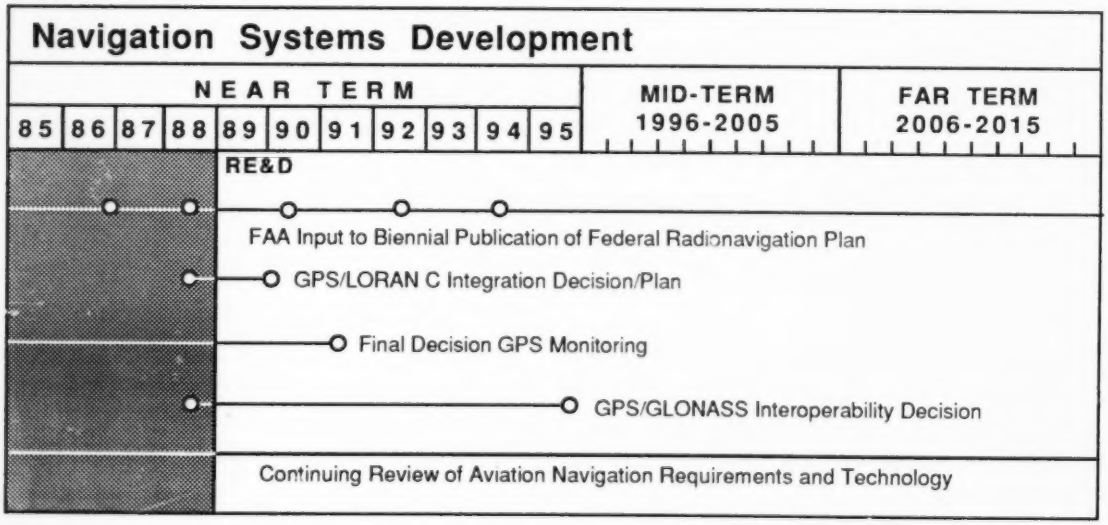
Recent Accomplishments

- Fourth edition of the FRP published May 1987.

Related Projects/Activities

- Improvements to Navigation Systems.
- Precision Approach and Landing.
- Satellite-Based Air-Ground Communications.
- Future Satellite C/N/S Systems Applications -- Will provide inputs to future updates of the FRP.

Project 5.3



6. Surveillance

This technical area includes ground-based surveillance of airborne aircraft and the surveillance of aircraft and ground vehicles on airport surfaces. Surveillance supports the safety, capacity, and efficiency mission areas. The following projects are included:

Ground-Based Surveillance	
6.1	Radar System Improvements
6.2	Low-Altitude Surveillance
6.3	Landing Monitor for Closely Spaced and Converging Runways
6.5	Sustain Automated Radar Terminal Systems (ARTS)
6.6	Special Surveillance System

Surface Surveillance	
6.4	Surface Traffic Surveillance

Ground-Based Surveillance

This function is currently provided by secondary and primary radar. The secondary radar, using a transponder on board the aircraft, transmits a response to an interrogation signal generated by the ground-based interrogators so that the ground site can measure range and azimuth angle. The primary radar makes these measurements without reliance on the aircraft transponder. The aircraft must also transmit its altitude, which is derived from the airborne altimeter. Shortcomings of the current surveillance system include altimeter errors; mutual interference resulting in garbled replies for the secondary radar; interference from birds, insects, and ground vehicles; and weak reflections from smaller aircraft for the primary system. The National Airspace System (NAS) Facilities and Equipment (F&E) Plan will provide a new secondary radar, Mode S, and three new primary radar systems: airport surveillance radar (ASR-9), air route surveillance radar (ARSR-4), and 2-dimensional (2D) long-range radar. This radar equipment will use digital technology to provide a surveillance capability with increased accuracy and reliability.

The Mode S, ASR-9, ARSR-4, and 2D long-range radar systems are expected to serve as the backbone of FAA surveillance through the year 2015. Surveillance of transponder-equipped aircraft will be provided by Mode S sensors, nearly 200 of which will be in service by the end of the near-term period. Improvements in primary radar coverage for terminal areas will be provided by the ASR-9, which incorporates modern moving-target-detector technology. ASR-9 radar will be operational at all terminal control areas (TCAs) by the end of the near term. En route coverage will be enhanced through the acquisition of ARSR-4 radar for deployment at joint-use sites. This implementation will free radar currently at these sites for use in upgrading equipment at other en route sites. The new 2D radar will be added to the surveillance network in the

mid-term. Through these acquisitions, the FAA will have surveillance sensors in place capable of providing primary and secondary coverage down to at least 6000 feet mean sea level or minimum en route altitude, throughout the contiguous United States.

The implementation of these improved surveillance sensors does not mean that development of the surveillance system has been completed. Additional development is needed to improve the quality of sensor data merging at the sensor site (for the integration of primary and secondary surveillance data) and at the air traffic control (ATC) facility (for the upgrading of multiple-sensor data processing). The realization of these improvements will result in higher quality, more reliable, and more standardized surveillance data that will reduce the processing requirements of functions using these data and improve the overall operation of the system.

Other types of radar technologies, such as new phased-array-type antennas, will also be investigated for suitable application.

Surface Surveillance

The goal of this activity is to provide a capability to detect, precisely locate, and identify all aircraft on the maneuvering area of an airport and to monitor the movement of ground vehicles operating in this area. An immediate requirement is the detection and prevention of runway incursions under low-visibility and low-ceiling conditions.

Current ground traffic monitoring and management are labor-intensive, utilizing visual and radar surveillance as well as voice communications. Equipment deficiencies and the communications procedures required to establish aircraft identity limit the number of operations possible during periods of low visibility. A primary need is the automated identification of aircraft under surveillance to support the development of automation features that will reduce the incidence of runway incursions. The Airport Surface Surveillance project will develop a technique for providing vehicle identification on the airport surface detection equipment (ASDE) display.

1 Radar System Improvements

esponsible Division

SA-100, Robert Valone

urpose

evelop radar data-processing algorithms necessary for new digital radar sensors. Establish rtification standards and procedures for new radar used in the terminal and en route air affic control systems.

Approach

The new NAS F&E Plan radar sensors differ from current radar systems in that they provide better positional accuracy and have only digital output. Current radar systems must be upgraded to provide the same capabilities. Radar certification procedures and standards must also be revised.

The project will develop radar-processing algorithms as follows:

- Examine characteristics such as Doppler velocity (which is available in the new primary sensor) for use as correlation criteria in surveillance tracking.
- Evaluate the use of primary and Mode S air traffic control beacon interrogator tracking data to improve track correlation.
- Analyze proposed algorithms with the simulated data.
- Evaluate live data collected at the FAA Technical Center.
- Refine real-time data from ASR-9 sites.
- Prepare specifications for primary surveillance, tracking, and combined tracker for future procurements and for a modification kit for existing sensors.

The present ASR-9/Mode S output will not support the necessary performance and accuracy equired by the Advanced Automation System (AAS) specification and Configuration Control ecision 8508. AAS testing activities will require input from a combined tracker in 1991, and mplementation will require tracker input from all of the ASR-9 and Mode S sites. In FY 1989, ork will be initiated on developing an integrated tracker and a testbed to support AAS testing. n FY 1990, these efforts will continue, along with additional work on supporting technical ata and test planning.

Products

- Specifications for combined tracker for future procurements.
- Specifications for a modification kit for delivered sensors.

- Test plan and report on combined tracker performance using Mode S and ASR-9 sensor configuration.
- Test and implementation plans and procedures for multisensor processing.
- Certification standards and procedures for new and upgraded radar systems.

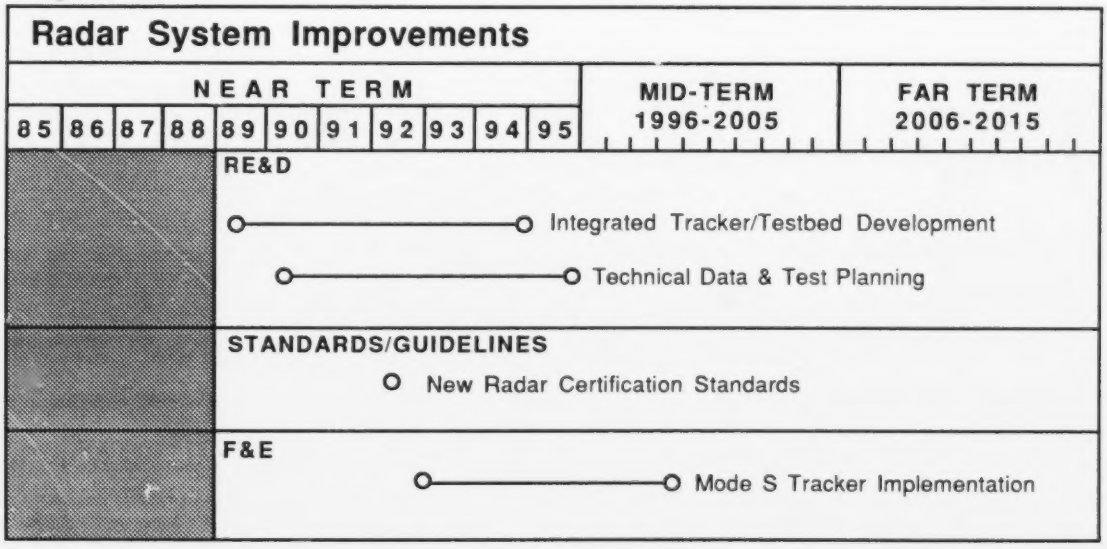
Recent Accomplishments

None - new start.

Related Projects/Activities

- Mode S (NAS F&E Plan) sensor operational testing will be required for primary surveillance tracking algorithm development.
- A multisensor processing algorithm will be implemented within the AAS software. The combined tracker output will meet AAS performance and accuracy requirements, which the current configuration cannot provide.

Project 6.1



.2 Low-Altitude Surveillance

esponsible Division

DS-200, William F. White

urpose

rovide surveillance and separation services to rotorcraft and fixed-wing aircraft, initially in ertain low-altitude and urban areas. Develop an all-weather surveillance system integrated ith the national aviation system for all low-altitude, offshore, and remote areas, and provide e surveillance system basis for low-altitude direct routings.

Approach

Formulate the functional and operational requirements for a low-altitude surveillance system hat will facilitate improved operations, routes, and designs in domestic and offshore airspace. Activities in the initial phase of this project include analyses of flight operations, air traffic control, and earlier technical studies [e.g., LORAN C Flight Following (LOFF)] to develop low-altitude surveillance system requirements. Cost-benefit analysis will be conducted on the candidate systems that can satisfy these requirements.

In its second phase, this project will develop the A-level functional design specifications for an integrated low-altitude surveillance system.

Products

- Low-altitude surveillance system requirements.
- Cost-benefit analysis.
- A-level functional design specifications.
- Design document.

Recent Accomplishments

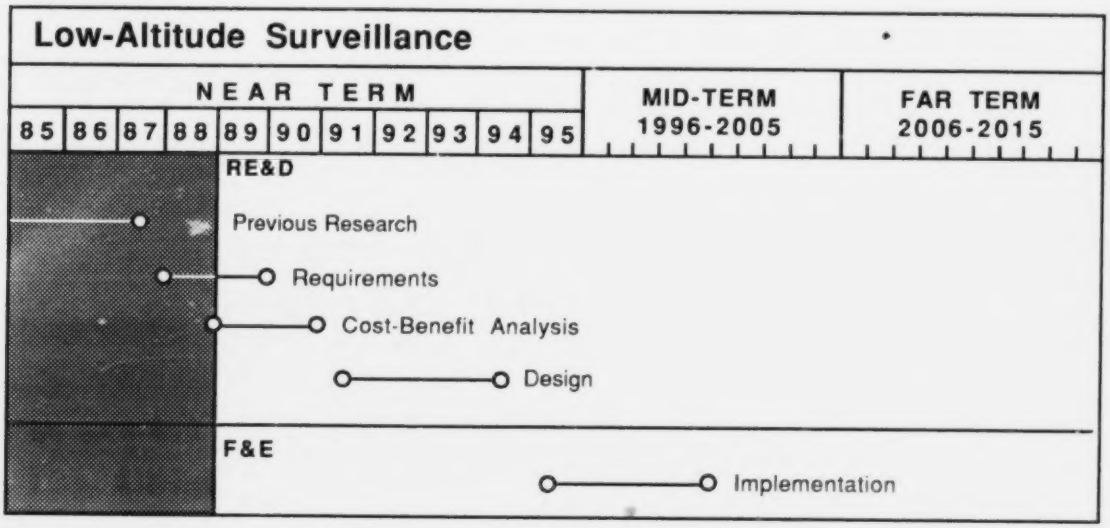
- Report on LOFF accuracy in comparison with radar accuracy in the Gulf of Mexico.

Related Projects/Activities

- Rotorcraft Master Plan -- Provides the overall plan for rotorcraft operations up to the year 2000.
- Low-altitude communications -- Will provide enhanced rotorcraft communications.

- Precision Approach and Landing -- Provides initial capabilities for the integration of rotorcraft and other special-application aircraft into the national aviation system.
- Rotorcraft/Power Lift Vehicles Obstruction Avoidance -- Will develop a model for analyzing rotorcraft wake-vortex hazards.

Project 6.2



6.3 Landing Monitor for Closely Spaced and Converging Runways

Responsible Division

ASA-100, Robert Valone
ADS-5, Anees Adil

Purpose

Develop improved surveillance of aircraft flying approach, landing, and missed approach flight paths for closely spaced parallel runways, triple runways, and converging runways to achieve increased airport capacities during instrument meteorological conditions.

Approach

A previous study suggested that independent operations at parallel runways separated by at least 3400 feet can be safely conducted when a sensor with a 1-milliradian (mrad) azimuth accuracy and a 2-second update rate is used to detect blunders. The study also showed that a sensor providing a 1-mrad/1-second update capability is required for 3000-foot parallel runway separations.

Alternative surveillance concepts will be examined, including back-to-back and electronically scanned antennas, a production Mode S sensor, and a production Mode S sensor modified for back-to-back antenna operations. Engineering models of an electronically scanned antenna sensor and a sensor having Mode S surveillance performance, called the air traffic control radar beacon system (ATCRBS) monopulse processing system, will be developed and deployed at Raleigh-Durham, North Carolina, and Memphis, Tennessee. The ATCRBS processing system will be equipped with back-to-back, 5-foot open-array beacon antennas to obtain 2.4-second update interval data.

An engineering testbed with variable azimuth precision (1-5 milliradians) and update rates (0.5 to 5 seconds) will be installed and tested at Raleigh-Durham to determine required technical characteristics for a landing monitor to reduce runway separations below the current 4300-foot standard. An evaluation of alternative system designs will also be conducted.

Measurements of instrument landing system aircraft trajectories in both visual and instrument meteorological conditions will be made to characterize parallel approach flight path deviations. This information will be used to support safety model validation and to test automatic blunder detection algorithms. Data will be gathered on targets of opportunity and on test aircraft flying blunder profiles. Both sensors will provide displays and automatic blunder detection alerts for evaluation by air traffic control personnel.

Cost-benefit studies will be performed to determine the best system solution for airports of interest. Operational procedures and guidelines will be established based on test results. Final production specifications for the electronically scanned and back-to-back rotary antennas will be developed for follow-on production procurements planned for FY 1990.

Products

- Operational requirements definition.
- Automatic blunder detection algorithms.
- Database of parallel approach aircraft trajectories.
- Validated runway separation safety model.
- Measured performance of alternative sensors, displays, and blunder detection algorithms.
- Procurement specification for production sensors or sensor modifications.
- Operational procedures and guidelines.
- Evaluation of high and medium data rate sensor system designs.

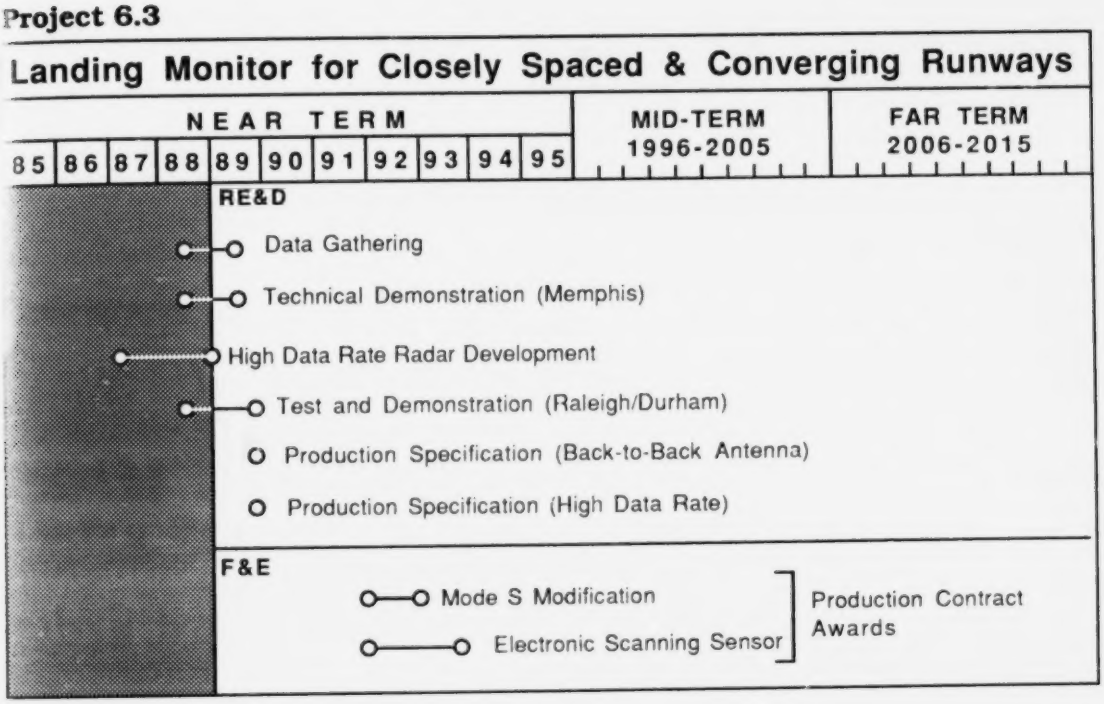
Recent Accomplishments

- Prototype high data rate system has been installed and is undergoing testing at Raleigh-Durham.
- The AMPS sensor with back-to-back antenna capability was installed at Memphis Airport.
- The data collection phase started.

Related Projects/Activities

- Mode S (NAS F&E Plan) -- Will provide production Mode S sensors, which would be modified for back-to-back antenna operation.

Project 6.3


Landing Monitor for Closely Spaced & Converging Runways
NEAR TERM
85 86 87 88 89 90 91 92 93 94 95
MID-TERM
1996-2005
FAR TERM
2006-2015
RE&D
Data Gathering
Technical Demonstration (Memphis)
High Data Rate Radar Development
Test and Demonstration (Raleigh/Durham)
Production Specification (Back-to-Back Antenna)
Production Specification (High Data Rate)
F&E
Mode S Modification
Electronic Scanning Sensor
Production Contract Awards

6.4 Surface Traffic Surveillance

Responsible Division

ASA-100, Robert Valone

Purpose

Provide automatic radar tracking, target identification, Mode S identification, and data link for improved airport surface traffic surveillance and communications. At high-density airports, these improvements will reduce the heavy workload of air traffic controllers responsible for the movements of taxiing aircraft and supporting ground vehicles.

Approach

ASDE radar allows tower controllers to monitor ground traffic during times of limited visibility. This project continues research aimed at enhancing ASDE radar to provide automatic radar tracking and target classification and adds Mode S to provide aircraft identification and data link capability.

Project activities are focused on three objectives:

- Develop a simple target classification technique for ASDE data. The initial instrumentation capability may involve a simple nonscanning system that will support the gathering of field measurements on a variety of targets. Output data from this radar will be recorded for subsequent use in the development and evaluation of techniques for classifying targets.
- Specify modifications to ASDE hardware and software to improve detection accuracy and the ability to track targets automatically. Enhancements will also include the capability to network multiple ASDE installations.
- Develop approach for the integration of Mode S with ASDE to permit target identification and data-link communications. Different configurations will be tested and evaluated at various locations using a surface measurements facility.

A transportable, integrated ASDE/Mode S testbed will be built and used to validate real-time performance. The resulting system will support both surveillance and data-link communications on the airport surface. RE&D will determine whether a separate data-link communications system for surface aircraft identification will be needed at airports not scheduled to receive an ASDE system.

Products

- System performance requirements in airport environment.
- Specifications for ASDE modification.
- Integrated ASDE/Mode S testbed.

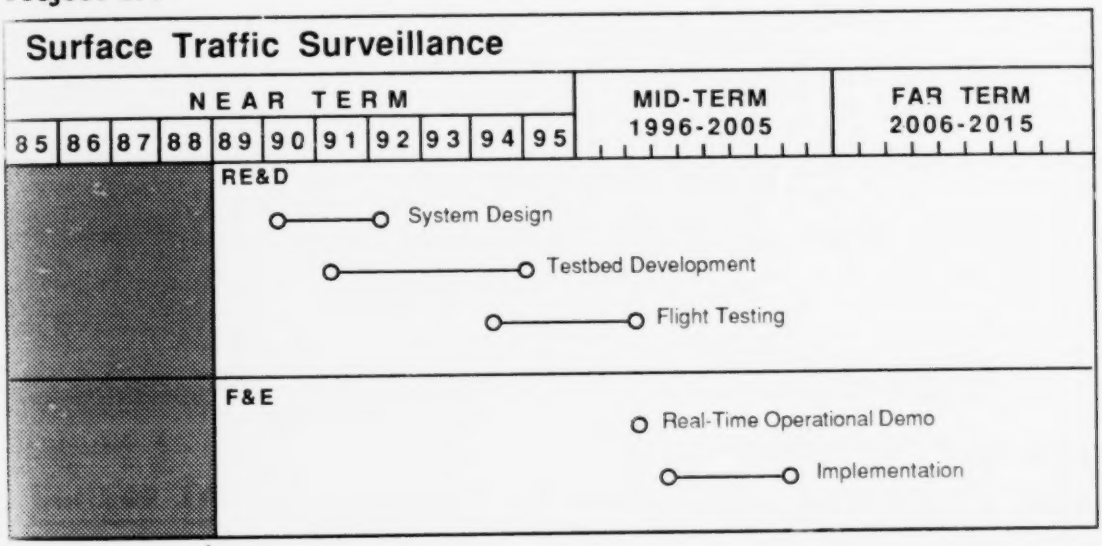
Recent Accomplishments

None - new start.

Related Projects/Activities

- ASDE 3 radar (NAS F&E Plan) will be installed at selected locations.
- Data-link applications development includes integrating enhanced ASDE with the Mode S data link so that aircraft identifiers are consistent and data communications can occur.

Project 6.4



6.5 Sustain Automated Radar Terminal Systems (ARTS)

Responsible Division

AAP-300, Charles Stith

Purpose

Ensure that ARTS availability, reliability, and capacity remains acceptable as demand increases. Until replaced by the AAS in the mid-1990s, ARTS computer equipment must continue to process airport radar data and provide necessary ATC services.

Approach

The FAA must define the improvements needed to extend the life of the ARTS and meet projected air traffic system requirements until approach control functions are consolidated during area control facility implementation in the latter half of the 1990s. ARTS enhancements will be developed to improve hardware and software efficiencies. These upgrades include software refinements that take full advantage of the processing efficiency and capacity increases brought about by the ASR-9/Mode S aircraft reporting capability.

Products

None.

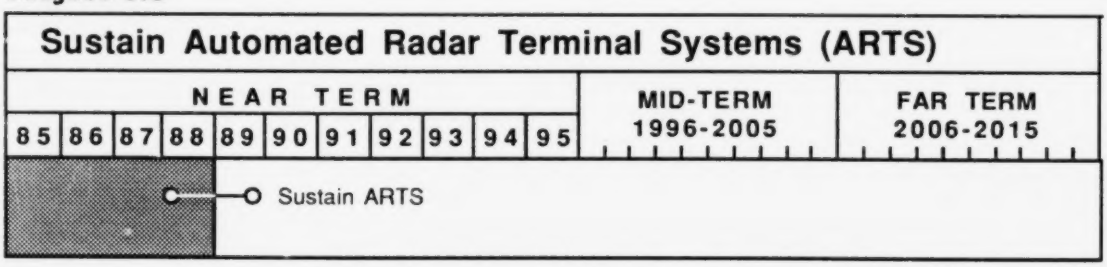
Recent Accomplishments

None.

Related Projects/Activities

- Advanced Automation System (AAS) -- Will replace ARTS in the mid-1990s.

Project 6.5



.6 Special Surveillance System

esponsible Division

SA-100, Robert Valone

urpose

etermine if the three-dimensional radar known as the special surveillance system (S3) will nhance safety by detecting intruders (aircraft unequipped with Mode C) violating TCA irspace, and assess the collision risk associated with such violations.

pproach

A three-dimensional radar system on loan from the U.S. Army will be modified for data collection and installed in the Los Angeles area.

A demonstration of this radar will take place between September and December 1988, during which time controllers will operate the S3 display and determine if such a radar can be used to enhance safety in the Los Angeles TCA.

Data will be collected during the entire period for analysis and quantitative risk determination. Results of this analysis will be used to determine future actions.

Products

- Data report.
- Risk assessment report.
- S3 safety enhancement report.

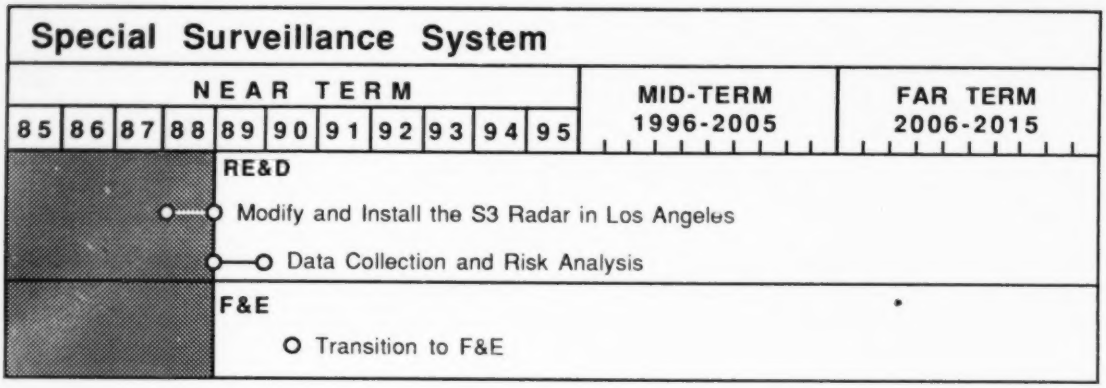
Recent Accomplishments

- Letter contract awarded to Hughes Aircraft for the demonstration activities.

Related Projects/Activities

None.

Project 6.6


Special Surveillance System
NEAR TERM
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MID-TERM
1996-2005
FAR TERM
2006-2015
RE&D
Modify and Install the S3 Radar in Los Angeles
Data Collection and Risk Analysis
F&E
Transition to F&E

7. Aviation Weather

Weather is, and will continue to be, a critical factor in all flight operations. It is the single largest contributor to delays and a major factor in aircraft accidents and incidents. Weather service users encompass the entire spectrum of flying, from the casual pleasure flyer to the operator of the most sophisticated, high-performance aircraft.

The projects in this technical area support the safety mission area and, to a lesser extent, efficiency and capacity. Projects are divided into two subareas: data acquisition and information distribution.

Data Acquisition

7.1	Next Generation Weather Radar (NEXRAD)
7.2	Terminal Doppler Weather Radar (TDWR)
7.3	Low-Level Windshear Alert System Enhancements

Information Distribution

7.4	LLWAS Voice Synthesis
7.5	Central Weather Processor (CWP)
7.6	Icing Forecasting Improvements

Routine weather data -- surface weather observations, winds and temperatures aloft, and area forecasts -- are required by pilots for strategic flight planning. Regulations mandate the use of surface weather observations for the conduct of flight operations. Information on hazardous weather conditions, such as windshear, gust fronts, thunderstorms, and poor visibility, is necessary for departure and landing decisions. Pilots also need information on severe weather, turbulence, and icing for en route tactical avoidance.

Today's system is primarily a manual one that is both labor-intensive and constrained by voice communications. It frequently fails to serve fully the needs of all flight operations. The aviation weather system of the future, currently being developed, must provide precise weather information to aviation users.

The goals of the FAA's aviation weather system development program are as follows:

- Increase the quality, frequency, and accuracy of weather observations.
- Improve the quality of weather analyses and forecasts, especially short-range forecasts.
- Increase the efficiency of the distribution of weather information.

The FAA can achieve these goals only through the cooperation and assistance of the National Weather Service (NWS), other government agencies involved in weather activities, the aviation industry, and system users. The successful achievement of these long-range goals will ensure that the aviation community is provided with maximum safety and the ability to operate economically.

The FAA has established a comprehensive plan for the development of the aviation weather system for the next decade. This plan, called the Aviation Weather System Plan, has brought into focus the various operational and research programs of all involved agencies that will directly support the achievement of the goals outlined above. This modernization plan addresses the phased development of aviation weather services. In addition, the windshear hazard to aviation is specifically addressed in the FAA's Integrated Windshear Program Plan. This plan addresses activities in five major areas:

- Education, training, operating procedures, and testing.
- Development and improvement of sensors for detection of low-altitude windshear.
- Terminal information systems.
- Airborne warning and flight guidance systems.
- Characterization of low-altitude meteorological hazards.

Data Acquisition

Weather observations assess the entire field of atmospheric and meteorological conditions. Such assessment includes the measurement of surface weather parameters and the visual examination of weather conditions; pilot reports and remote sensing of the upper atmosphere by radar, balloon sounding, satellite, and automatic aircraft reports; and detection and tracking of convective storms by radar.

Today, surface observations require a series of manual and labor-intensive tasks. A key development program is jointly sponsored by the FAA and the NWS to automate the process of acquiring surface observations. Procurement, installation, and maintenance of automated systems will be under the program management of the NWS.

The FAA is planning to procure 160 of these systems off the shelf to meet an urgent need for weather observations, primarily at nontowered airports with instrument approaches. The FAA's off-the-shelf systems will have several configurations to measure some or all of the following parameters: ceiling, visibility, wind data, temperature, dewpoint, pressure (altimeter setting), and density altitude. The measured data will be automatically processed and formatted for distribution. Data distribution will be either through computer-generated voice by radio broadcast or telephone, or through digitized data transmission by land-line or microwave link. The system will be capable of operation in either an attended or unattended configuration. It will be of modular design, permitting additional sensors to be incorporated.

The FAA is also working with the NWS on the procurement of over 500 systems for towered and nontowered airports for installation in the 1990s. These systems, being procured by NWS for the FAA, are similar in design and employ the same basic sensors, with the addition of a present weather sensor and a cloud height measurement to above 10,000 feet. The automated surface weather observing systems developed in the near term will also identify types of precipitation. The FAA and NWS will continue to enhance the capability of these systems.

In the current system, the acquisition of upper-air data is basically accomplished through balloon soundings, an expensive and labor-intensive method. For a number of years, the National Oceanic and Atmospheric Administration (NOAA) has been developing new techniques and equipment for sounding the upper atmosphere. Engineering models of ground-based tropospheric very high frequency/ultra-high-frequency radar wind profilers and microwave radiometers for temperature and water vapor soundings, capable of measurements from the surface to approximately 60,000 feet (FL600), have been developed and tested. A 30-station Profiler network will be installed in the midwest in 1989, beginning a 5-year operational evaluation. Satellite-based infrared radiometric sounders are also being evaluated. In the year 2000 and beyond, the aviation system will be provided with accurate and current global upper-air data from the combined deployment of these types of systems. With the advent of worldwide air-ground digital data links, atmospheric measurements automatically acquired by aircraft will also be incorporated into both national and international meteorological centers and databases.

Another joint program, involving the Department of Transportation, Department of Defense (DoD), and Department of Commerce, is the development and deployment of the Next Generation Weather Radar (NEXRAD). This program is directed by a Joint System Program Office that is funded and staffed by the FAA, NWS, and the U.S. Air Force. NEXRAD prototypes are being fabricated by two competing contractors and will undergo full operational testing and evaluation; a production contractor will then be selected. A nationwide network of radar that will meet the weather detection needs of the FAA, NWS, DoD, and other government and private organizations will be deployed under this program.

The FAA has initiated a separate project for the development of a Terminal Doppler Weather Radar (TDWR) for detecting windshear and hazardous weather in the immediate vicinity of an airport. The deployment of Doppler weather radars at major airports that are subject to frequent hazardous windshear conditions and severe convective storm activity will supplement the en route coverage of the NEXRAD network and greatly enhance the safety and efficiency of airport operations. Weather data provided by this radar will improve "nowcasts" of terminal conditions and provide real-time weather information to pilots and air traffic control (ATC) facilities.

Analysis and Forecasting

Weather analysis and forecasting are primarily an NWS responsibility. The FAA establishes operational requirements for aviation weather services and products and assists NWS in the acquisition of basic weather data, as well as the distribution of data and finished weather products.

The FAA supports the national stormscale operational and research meteorology program. This long-range research program is specifically aimed at developing near-real-time analyses and forecasts of mesoscale weather for operational applications.

Additionally, it is anticipated that the central weather service unit (CWSU) meteorologists located at each area control facility (ACF) will play an expanded role in nowcasting -- much along the lines of today's weather advisory product. Sophisticated weather data

processors and interactive workstations are being designed to support aviation's need for the rapid transfer of information and high-quality forecasts.

Once the planned aviation weather system elements are in place, efforts will be aimed at developing a centralized database of all weather products, as well as automated means for the input and output of weather information, so that consistency in the information available to users can be maintained. When fully automated, the system will generate routine and hazardous weather products for each pilot-defined route, and these products will be automatically disseminated to the cockpit.

Information Distribution

The finest-quality forecasts and the most accurate weather assessments are of marginal benefit if they are not translated into practical information that is delivered to the user at the proper time. The majority of the FAA's investment in the planned aviation weather system is in the area of data handling and distribution. Near-term projects, such as the Central Weather Processor (CWP), Aviation Weather Processor, Weather Communications Processor, Mode S data link, National Airspace Data Interchange Network, National Airspace System (NAS) interfacility communications system, and the Weather Message Switching Center Replacement, are all designed to expedite the flow of information throughout the aviation system.

.1 Next Generation Weather Radar (NEXRAD)

esponsible Division

SA-200, Carey L. Weigel

urpose

pply the new generation of Doppler weather radar, which provides accurate information on recipitation, wind velocity, and turbulence, and develop new software algorithms to take naximum advantage of the improved detection of these weather data. This will improve azardous weather detection, reduce flight delays, and improve flight planning.

Approach

The FAA has joined with the NWS and the U.S. Air Force Air Weather Service in a program designed to develop and deploy the NEXRAD system. In general terms, NEXRAD requirements can be broken down into five areas: detection, signal processing, weather product generation, display, and reliability and maintainability. The NEXRAD system must have sufficient sensitivity to detect very weak signals, such as those from gust fronts in the absence of precipitation, and to detect light to moderate precipitation from a distance of about 150 miles. NEXRAD signal processing is required to eliminate signals that could contaminate the measurement of weather phenomena, such as ground clutter. The NEXRAD system uses basic weather measurements made at different elevation angles to provide accurate indicators of the presence of hail, turbulent areas, and tornadoes. The FAA is also developing the CWP for the distribution and display of NEXRAD data. The CWP will collect data from many NEXRAD systems and integrate these data into regional composite pictures for FAA users. NEXRAD reliability and maintainability specifications require that the system rarely fail and that repairs take less than 30 minutes, with the help of automated diagnostics.

NEXRAD will be used to provide hazardous and routine weather radar data for all altitudes above 6000 feet throughout the contiguous United States, except over mountainous areas in the west where the lower altitude will be 10,000 feet. Weather radar coverage will also be provided for selected areas in Alaska, Hawaii, and the Caribbean.

NEXRAD provides several aviation weather products related to winds, windshear, turbulence, thunderstorm detection, storm movement prediction, precipitation, hail, frontal activity, icing conditions, mesocyclones and tornadoes, and hurricanes. Meteorological algorithms exist for many of these products. The FAA is devoting considerable research activity to the development of windshear and icing algorithms. To identify unique radar detection signatures, icing phenomena data will be analyzed in FY 1989; in FY 1990, a NEXRAD software enhancement will be documented and tested. Further RE&D efforts may be required for the validation and enhancement of algorithms needed to meet the requirements of weather products for air traffic control, including the weather radar data needed for the CWP.

Products

- Prototypes.
- Specifications of windshear algorithms, icing algorithms, and NEXRAD software enhancements.

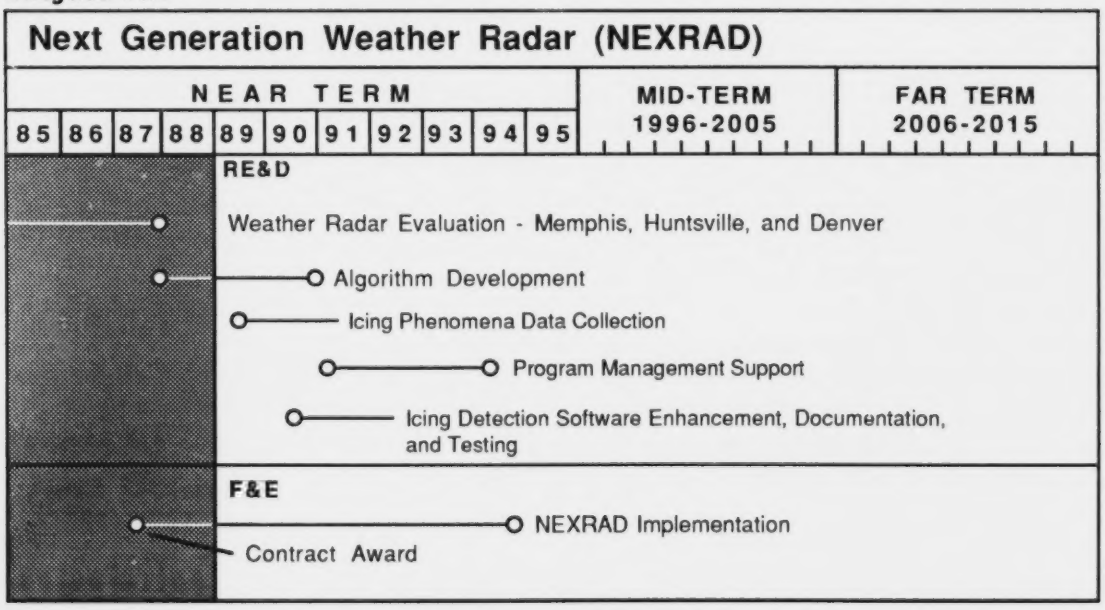
Recent Accomplishments

- Weather radar support tests completed at Memphis, Tennessee; Huntsville, Alabama; and Denver, Colorado.
- Operational test of NEXRAD application in terminals completed at Denver 8/31/88.
- Limited production contract for 10 units awarded 12/87. Weather radar support facility established at Denver, Colorado, for operational testing of NEXRAD terminal applications and for data acquisition, development of meteorological algorithms, and evaluation of radar performance.

Related Projects/Activities

- Central Weather Processor (CWP) -- Will distribute weather radar data.
- Weather Radar Program [NAS Facilities and Equipment (F&E) Plan] -- Will establish an aviation weather radar network.
- Terminal Doppler Weather Radar (NAS F&E Plan).

Project 7.1



.2 Terminal Doppler Weather Radar (TDWR)

:esponsible Division

SA-200, Carey L. Weigel

'urpose

nprove the identification of dangerous windshear and other weather events by measuring ind fields in the terminal environment.

\pproach

TDWR was developed for the detection of hazardous weather in terminal airspace, analogous to NEXRAD functions in en route airspace. This radar is being deployed at major airports that experience frequent occurrences of hazardous windshear conditions and severe thunderstorms. Technical specifications for scanning rates and strategies, data update rates, fully automatic generation of radar products, ground clutter suppression, and controller-display interface were developed.

Research will be conducted to explore lower cost windshear detection systems for airports for which a full-scale TDWR cannot be justified. The use of airport surveillance radar, lasers, and infrared detectors will be explored.

Work will also continue on microburst windshear detection and prediction, using Doppler radar techniques. Data will be acquired for different elevation angles, scan techniques, precipitation levels, and environments. Wind-field patterns and signal levels will be analyzed to determine signatures of dangerous windshear events. Algorithms will be developed to identify hazard locations and characteristics and to provide guidelines for controller and pilot actions.

Products

- Detection and identification algorithms for windshear and other hazardous weather documented and tested in FY 1990.
- Windshear detection system.

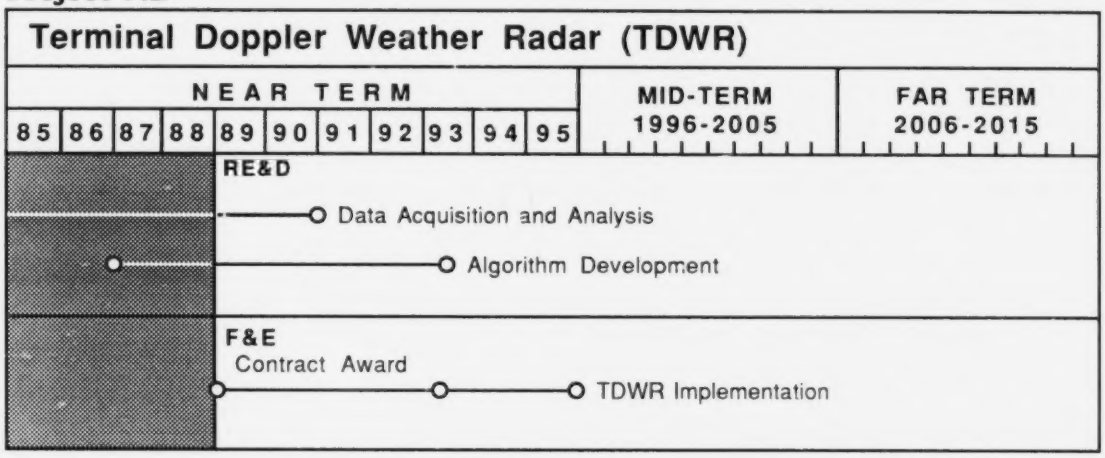
Recent Accomplishments

- Contract awarded for 47 units 9/88.
- Detection of precipitation and clear-air wind patterns by Doppler radar demonstrated.
- Identification of lower cost systems.
- Detection of microbursts by Doppler radar demonstrated.

Related Projects/Activities

- Low-Level Windshear Alert System Enhancements -- Will provide research on increased detection probability, reduced false alarms, improved interpretability, and procedures for identifying hazard characteristics of windshear.
- Next Generation Weather Radar (NEXRAD) -- Will develop Doppler radar applications for weather sensing and provide initial systems for installation at selected airports.

Project 7.2



7.3 Low-Level Windshear Alert System Enhancements

Responsible Division

APS-500, Norm Fugisaki

Purpose

Improve windshear identification performance of the Low-Level Windshear Alert System (LLWAS) with respect to increased detection probability, reduced false alarms, and improved interpretability. Develop procedures based on identified hazard characteristics in order to provide improved warnings to pilots.

Approach

LLWAS algorithms are being developed to improve windshear detection at airports, including the new Denver mega-airport, enabling controllers to issue advisories to pilots on windshear hazards. In FY 1990, a new algorithm developed in 1989 will expand LLWAS coverage to 3 miles from runway ends. In FY 1989 to 1990, windshear information from LLWAS and TDWR will be defined and evaluated during a test at Denver. Studies will be conducted to determine how these two systems can be combined into an integrated capability, and a single windshear display will be developed. In FY 1990, operational procedures will be established for rapid and appropriate response by controllers and pilots in the event of a dangerous windshear event. New sensors that can withstand the effects of icing will be tested. Algorithms will be developed to provide remote maintenance monitoring capability in FY 1990.

Products

- Enhanced LLWAS windshear detection and identification algorithms.
- LLWAS operational guidelines.
- Integrated LLWAS/TDWR display specifications.
- Improved LLWAS sensors.
- Siting criteria.
- Report on icing effects on sensor.
- Maintenance diagnostics.

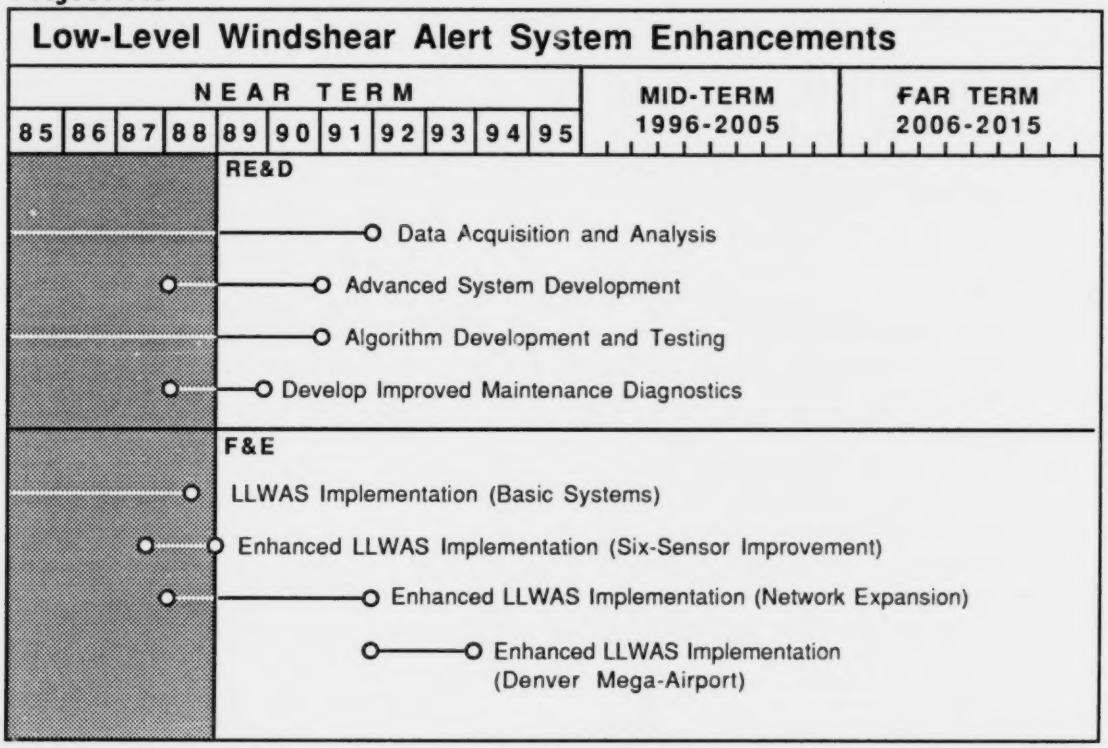
Recent Accomplishments

- Six-sensor LLWAS improvements initiated with 48 upgrades completed.
- Sensor algorithm completed.
- Runway-oriented wind algorithms developed and software installed at New Orleans and Denver.

Related Projects/Activities

- Terminal Doppler Weather Radar (TDWR).

Project 7.3



7.4 LLWAS Voice Synthesis

Responsible Division

APS-500, Norm Fugisaki

Purpose

Demonstrate the timely, automated communication of LLWAS warnings to pilots during terminal operations. Voice synthesis is being considered to ensure immediate recognition of warnings.

Approach

Automated transmission of windshear alerts directly to pilots via computer-generated voice or data-link message will be developed, tested, and evaluated. (Presently, LLWAS messages are presented to air traffic control for dissemination to flight crews.) The intent of this project is to uncover the benefits and deficiencies of simultaneously alerting the flight crew and air traffic system. Message structure will be developed for efficient transmission of alert data. LLWAS field data will be used throughout the evaluation.

In FY 1989, a feasibility evaluation will be performed to assess how synthesized voice can be taken from LLWAS data and sent to flight crews and the air traffic system. In FY 1990, evaluations at New Orleans in a simulated environment with flight crews and air traffic will compare a voice-synthesized environment with established methods. Finally, an operational demonstration will evaluate this type of service.

Products

- Feasibility evaluation to assess synthesized voice from LLWAS data.
- Simulation evaluations with flight crews and air traffic.
- Operational demonstration to evaluate synthesized voice.
- LLWAS direct-voice system description.

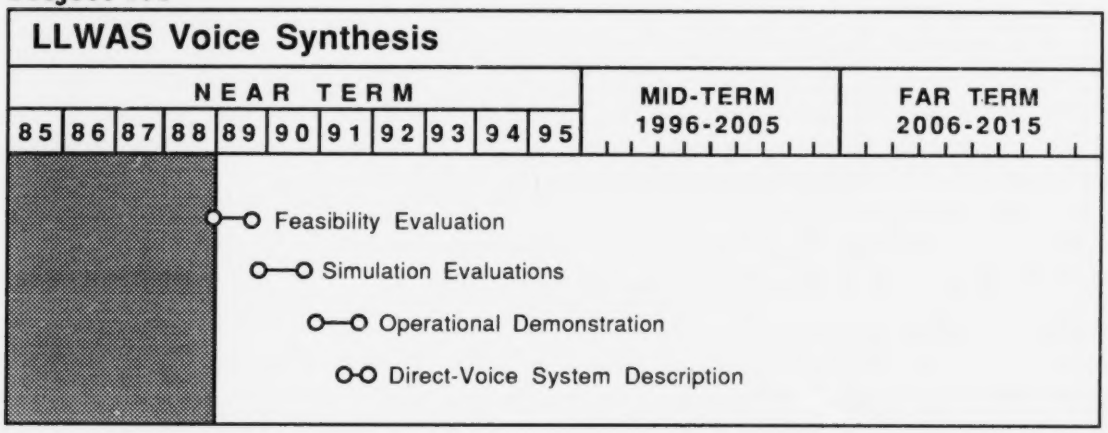
Recent Accomplishments

- LLWAS Voice Synthesis Research Plan.

Related Projects/Activities

- Windshear training aid.
- Low-Level Windshear Alert System Enhancements.
- Terminal Doppler Weather Radar (TDWR).
- Airborne Windshear Detection and Avoidance.
- ATC Weather Information Transfer.

Project 7.4



.5 Central Weather Processor (CWP)

esponsible Division

SA-200, Carey L. Weigel

urpose

evelop, test, and evaluate a distributed computer capability that will process and disseminate eal-time weather information for pilots and air traffic controllers. Processors will be installed n each ACF.

pproach

The Central Weather Processor is composed of two elements: a meteorologist weather processor (MWP) and a real-time weather processor (RWP). The MWP will be procured through a series of leases beginning in the near term. This will provide modern automation support and weather displays to the weather analysis and forecasting functions of the CWSU in each air route traffic control center (ARTCC) and in the central flow control facility.

The RWP will provide time-critical information on hazardous and operationally significant nonhazardous weather; this information will be used by pilots in flight and by air traffic controllers. The RWP will generate weather products that are easy to interpret, transmitting them to the Advanced Automation System for use by ATC personnel. It will also transmit a subset of its weather products to the data-link processor (DLP) for uplink to pilots via Mode S. In addition, the RWP will provide the CWSU meteorologist's workstation with a limited capability to display and manipulate the weather products in its database, as a complement to the meteorologist interface provided by the MWP.

RWP prototype development will continue in FY 1990, including acceptance, testing, and operational testing and evaluation, which will include adapting the RWP prototype to an ARTCC/ACF environment. In addition, enhancement packages will be developed to accommodate new real-time weather sources and other new interfaces, such as the RWP/MWP and CWP/data-link processor. These interfaces will enhance the benefits of CWP, providing better and faster weather information to controllers, pilots, and traffic management specialists. Specifications will be updated to support these interfaces and will be defined for the second generation MWP. Work will include initial studies, requirements definition, interface requirements, documents development, and in-house management of interfaces. The FY 1990 request covers the completion of work on interface requirements documents for the CWP, RWP specification to support these interfaces, and the definition of requirements for the second generation MWP.

Products

- Leased MWP systems.
- RWP prototype.

- RWP production specifications.
- Test reports.
- RWP enhancement packages.
- Second generation MWP requirements.

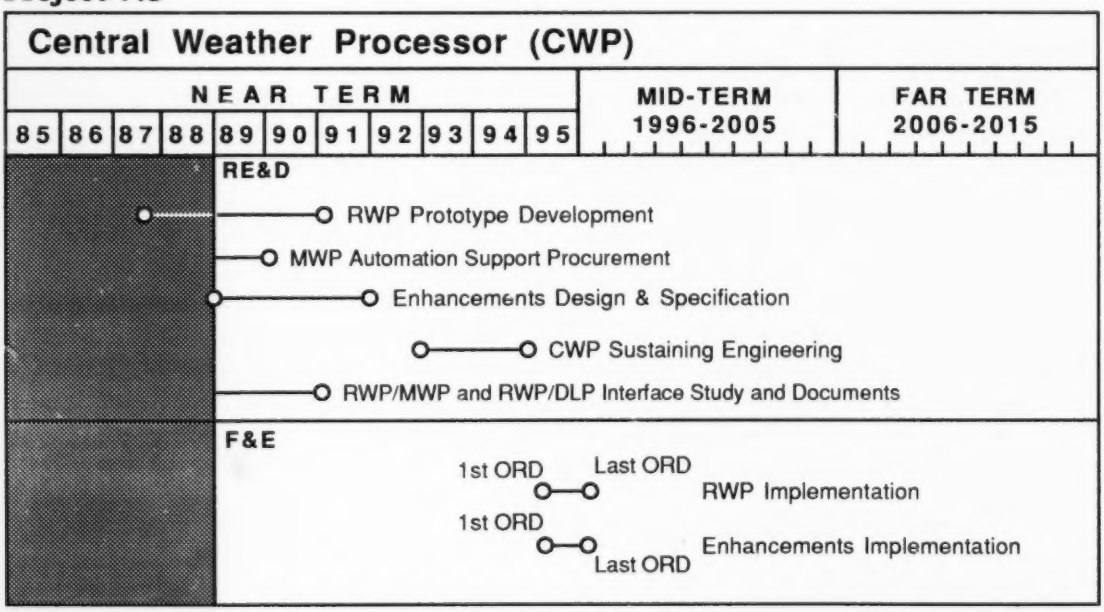
Recent Accomplishments

- Interface with NEXRAD demonstrated.

Related Projects/Activities

- Weather Radar Program (NAS F&E Plan) -- Will provide NEXRAD weather information.
- Automated Weather Observing System (NAS F&E Plan) -- Will provide real-time automated surface observations.
- Data-link enhancements -- Will communicate RWP graphical weather radar information to pilots via the DLP and Mode S data link.
- Weather Message Switching Center Replacement (NAS F&E Plan) -- Will provide weather product exchange between the CWP and the NWS's telecommunications gateway serving the National Meteorological Center.

Project 7.5



.6 Icing Forecasting Improvements

esponsible Division

SA-200, Carey L. Weigel

urpose

rovide pilots with a more timely, accurate delineation of actual and expected icing areas by cation, altitude, duration, and potential severity.

pproach

The project will study the ability of the new generation of remote sensors to detect icing conditions, evaluate current and new icing forecasting techniques, and provide the technology transfer necessary to implement the best techniques into the day-to-day operations of the NWS. This research. a cooperative effort with the NOAA, DoD, and the National Science Foundation, will carry out the program defined by the National Plan to Improve Aircraft Icing Forecasts.

Preliminary work leading to a detailed program plan was begun in FY 1987 and will continue through FY 1989. Funding for this portion has come mainly from the Office of the Federal Coordinator for Meteorological Services and Supporting Research. In FY 1990, the 3-phase, 6-year program will begin in earnest, with a 3-year field test. This field test will use research aircraft and the NOAA's experimental mesoscale remote sensing facilities to study the ability of remote sensors to detect icing conditions, evaluate current icing forecasting techniques, and test promising new techniques.

The emphasis of this first phase will be on improvements in the detection of icing conditions and in short-term (up to 4 hours) forecasting. Phase II will be a 2-year effort aimed at further improvements in both short- and long-term (4 to 12 hours) forecasting. Phase III is a 1-year effort to adopt the new forecasting techniques in all regions of the national aviation system and apply them to the daily operations of the FAA's weather services.

roducts

- Atmospheric data sets which will support this program as well as others.
- New aircraft icing forecasting techniques.
- Improved aviation icing forecasts.

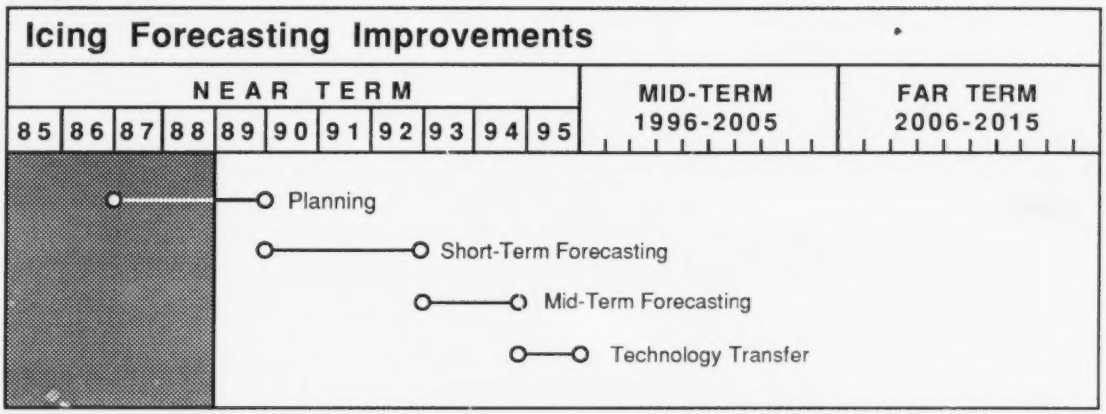
Recent Accomplishments

None.

Related Projects/Activities

None.

Project 7.6



NOTE: Funded 1987 through 1989 by the Office of the Federal Coordinator for Meteorological Services and Supporting Research.

8. Satellite Applications

Satellite systems have the potential for providing communications, navigation, and surveillance (C/N/S) services for civil aviation on a global basis. The maturing of satellite technology has substantially increased interest in satellite systems, although questions remain concerning their application in an aviation environment and their economic viability. The two projects described in this chapter support the decision-making process regarding satellites by permitting better informed judgments about the proper role of satellite systems. These projects are:

Satellite Applications

8.1	Satellite-Based Air-Ground Communications
8.2	Future Satellite C/N/S Systems Applications

Satellite-Based Air-Ground Communications

The objective of this program is to provide the technical support necessary for the development and implementation of satellite-based communications capabilities that will be suitable for the transmission of all types of air-ground data for air traffic control (ATC) communications and surveillance purposes. The program will provide concept definition, analysis, evaluation, performance validation, and experimental testing of satellite-based air-ground communications techniques and systems for use in the national aviation system. An important element of this program is the FAA's active involvement in the development of system standards for satellite air-ground communications systems. This will include participating in the Airlines Electronic Engineering Committee, International Civil Aviation Organization (ICAO) activities, and Radio Technical Commission for Aeronautics (RTCA) Special Committees.

Long-Range Satellite C/N/S Systems Applications

A comprehensive study will be conducted to determine the most effective applications of satellite technologies for future C/N/S services. The study will begin with a validation of operational requirements (FAA, RTCA, National Airspace Review, and others) and the development of functional requirements. This will be followed by an examination of technical concepts, including an analysis of costs, benefits, and availability schedules. Much of the technology analysis and projection effort will be done in cooperation with the National Aeronautics and Space Administration (NASA). The results of these analyses will be used as a measure of the reasonableness of the requirements, and the subsequent addition, deletion, or modification of requirements will be coordinated with their original sponsors. Alternative satellite C/N/S technologies and systems will be developed on the basis of C/N/S requirements and projected satellite-based techniques.

This project will provide the FAA with a framework and road map for incorporating future satellite technology into the aviation system. System design will be dynamic, so that it may be adjusted as changes occur in user requirements, technology, and costs. The study will

address the expansion of C/N/S services to oceanic airspace and to low-altitude, offshore, and remote regions on a national and global scale. It will also encompass institutional and transition issues, such as owner and operator relationships and international coordination.

The introduction of satellite services into the future aviation system will depend upon many factors, including the validation of user requirements, costs, performance characteristics, and service availability schedules. A principal advantage of satellites, especially those in high-altitude orbits, is their excellent line-of-sight coverage for aircraft flying at low altitudes and over remote and oceanic regions of the earth. The global positioning system (GPS) will provide a near-term opportunity for extending the navigation services offered to civil aviation. This system will consist of 21 satellites and 3 active spares distributed in 6 orbital planes at an altitude of 10,900 nmi. This satellite constellation will provide signals in space that will allow equipped aircraft to determine their position and velocity in three dimensions. GPS will also provide precise time information. The 100-meter, 2 drms accuracy of GPS will be a factor in the success of the long-term application of automatic dependent surveillance (ADS).

Several groups have been chartered to investigate the opportunities offered by satellites for the ATC system of the future. RTCA Special Committee (SC)-155 was initiated to assess future C/N/S requirements and system concepts and has provided recommendations to the FAA for consideration in the development of future ATC services. The ICAO Future Air Navigation Systems (FANS) Committee was formed to evaluate the application of satellites and other forms of advanced technology to global air traffic management systems of the future. In addition, the FAA has established a special task group to provide an assessment of aeronautical L-band frequency spectrum requirements, including a description of representative satellite system concepts. These and other investigations have provided a preliminary perspective on the system scenarios that can be used in the examination and development of C/N/S system options for the future.

.1 Satellite-Based Air-Ground Communications

esponsible Division

DS-100, Clyde Miller

urpose

rovide the technical support necessary for the development of satellite-based air-ground ommunications systems to meet near-term ATC voice and data transmission needs.

pproach

Develop air-ground communications requirements for currently defined and projected satellite operations, including ADS. Issues related to transitioning from ground-based to satellite-based systems will be documented. The critical issues relating to sharing the spectrum available for satellite-based aeronautical services will be addressed in cooperation with the FAA and other spectrum management organizations.

The overall approach is to investigate alternative system concepts and applications, select candidate system configurations, and evaluate and test these configurations. Performance analyses of the selected elements and system configurations will then be accomplished through investigations, simulations/emulations, and laboratory tests. Following these investigations, performance validation and experimental testing of the most promising techniques will be demonstrated, using satellite and ground terminal resources. This phase of the project may involve a cooperative effort with NASA and with other organizations having expertise in the satellite and terminal resources available for FAA experimental use. Cost-benefit analyses for satellite air-ground communications systems will be provided. Project activities will be coordinated with domestic and international organizations engaged in the formulation, development, and assessment of standards for satellite-based air-ground communications.

Products

- A summary report on requirements for air-ground communications services.
- Operational and procedural requirements for system integration into the air route traffic control center.
- Review of national and international standards for air-ground communications services.
- Test procedures for certification of satellite-based air-ground communications.
- Cost-benefit studies.
- Study of spectrum-sharing considerations for aeronautical L-band.

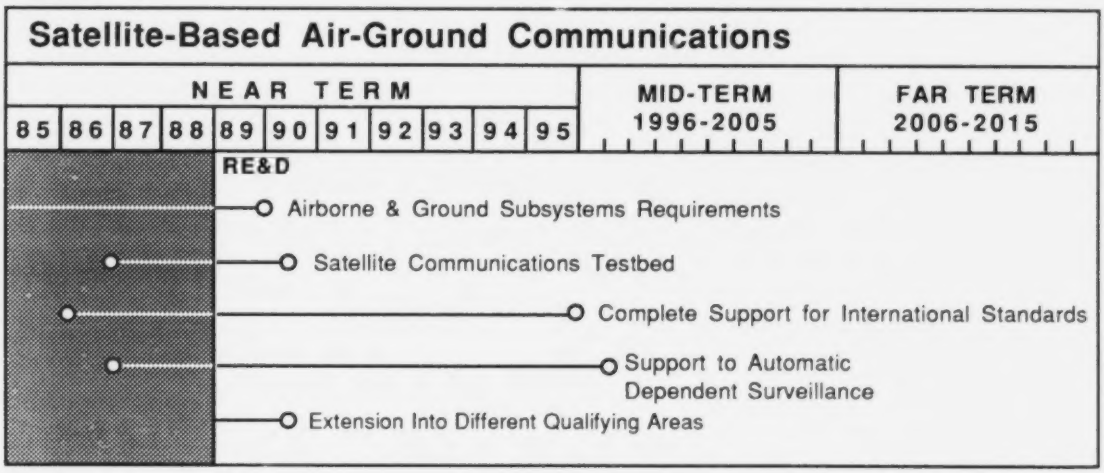
Recent Accomplishments

- Started development of satellite communications test facility at the FAA Technical Center.

Related Projects/Activities

- ATC Applications of Automatic Dependent Surveillance -- Will provide technology for oceanic surveillance.
- Data-link applications development -- Will develop the operational applications of the Mode S data link.
- Future Satellite C/N/S Systems Applications -- Will develop satellite-based C/N/S systems for integration into the national aviation system.
- International standards establishment through the ICAO.

Project 8.1


Satellite-Based Air-Ground Communications
NEAR TERM
MID-TERM 1996-2005
FAR TERM 2006-2015
85 86 87 88 89 90 91 92 93 94 95
RE&D
Airborne & Ground Subsystems Requirements
Satellite Communications Testbed
Complete Support for International Standards
Support to Automatic Dependent Surveillance
Extension Into Different Qualifying Areas

8.2 Future Satellite C/N/S Systems Applications

Responsible Division

ADS-100, Clyde Miller

Purpose

Develop satellite-based C/N/S systems for integration into the national aviation system. Provide the C/N/S capabilities needed to meet long-range system demands.

Approach

Develop alternatives to current C/N/S systems to expand coverage to areas where existing services are limited and to augment or replace these services. Validate user requirements for modified and extended C/N/S services, including the requirements identified by RTCA SC-155 and ICAO FANS. Address future communications requirements for both voice and data and analyze the requirements for the continental United States and low-altitude, remote, oceanic, and worldwide areas. Assess candidate C/N/S systems and emerging technologies for potential use in the FAA's overall C/N/S system design, test, and implementation strategy. Assessments will include detailed analyses of new C/N/S and precision approach techniques, including technical and economic characteristics, risk factors, transition strategies, and availability. These assessments may include laboratory simulations and operational testing of prototype equipment to establish the feasibility of the techniques; they will also include definitions of the processes by which satellite technology will be integrated with ground-based services. The project may utilize the background and expertise of NASA in the assessment and testing of space-related technologies.

The project will include assessments of such issues as owner and operator relationships, international coordination of C/N/S services, technical standards, and integration with prevailing air-ground systems. Studies will be made of the capabilities of satellite-based technologies and systems in the following areas:

- Communications
  - Oceanic, remote-area, and low-altitude satellite-supported air-ground communications.
  - Domestic air-ground integrated voice-data satellite communications.
- Navigation
  - Alternative satellite techniques for civil air navigation.
  - Satellite-based techniques for approach and landing.

- Surveillance
  - Satellite-based techniques for dependent surveillance coverage in the continental United States and in oceanic, remote, and low-altitude regions.
  - Satellite-based independent surveillance studies, including investigations of cooperative-independent, space-based radar.
- Integrated C/N/S systems
  - Functions.
  - Avionics.
  - Integration issues.

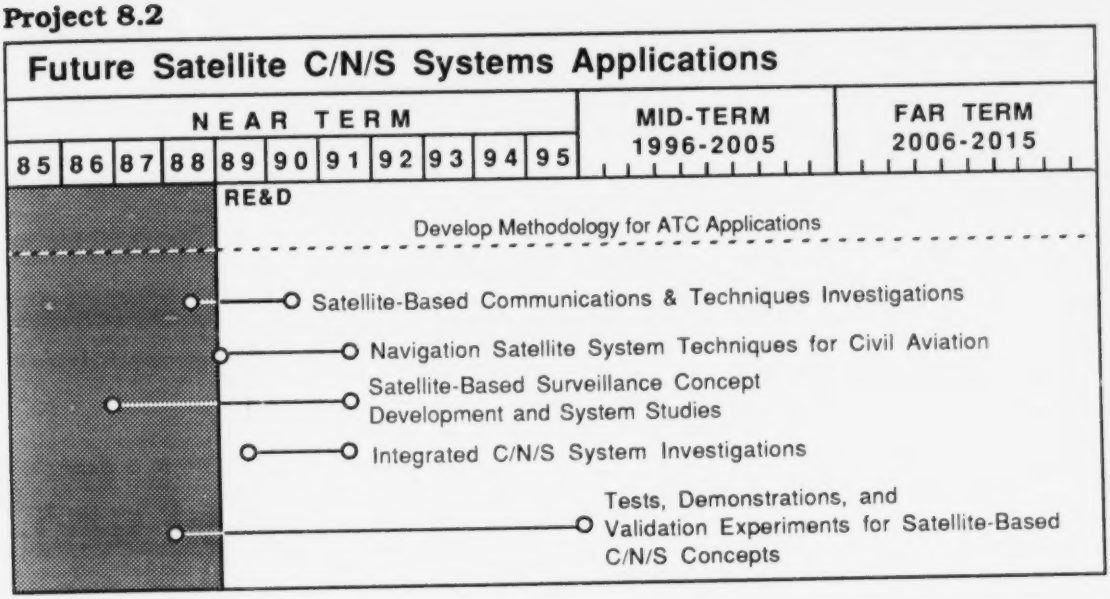
Products

- A summary report on the recommended C/N/S applications, technologies, and concepts.
- Technical and economic assessment reports on satellite-based concepts and systems for the following:
  - Communications.
  - Navigation.
  - Surveillance.
  - Integrated C/N/S.
- Requirements for Satellite C/N/S systems.

Recent Accomplishments

None.

Project 8.2


Future Satellite C/N/S Systems Applications
NEAR TERM
85 86 87 88 89 90 91 92 93 94 95
MID-TERM
1996-2005
FAR TERM
2006-2015
RE&D
Develop Methodology for ATC Applications
Satellite-Based Communications & Techniques Investigations
Navigation Satellite System Techniques for Civil Aviation
Satellite-Based Surveillance Concept
Development and System Studies
Integrated C/N/S System Investigations
Tests, Demonstrations, and
Validation Experiments for Satellite-Based
C/N/S Concepts

9. Airborne Systems

Airborne systems RE&D addresses the requirements and development of airborne, ground-independent electronic systems. These projects, listed below, support the safety major mission area.

Airborne Systems

9.1	Traffic Alert and Collision Avoidance System (TCAS)
9.2	Airborne Windshear Detection and Avoidance
9.3	Rotorcraft/Power Lift Vehicles Obstruction Avoidance

The first project in the airborne systems program area, the Traffic Alert and Collision Avoidance System (TCAS), is intended to provide a ground-independent, airborne collision avoidance capability to reduce the risk of midair collisions.

The second project involves the investigation of onboard sensors for detecting hazardous windshear. Airborne windshear detection is intended to provide the pilot with lookahead techniques for early warning.

The third project in this area is aimed at developing technology and methods to detect and avoid rotorcraft/power lift vehicle obstructions at low altitudes.

9.1 Traffic Alert and Collision Avoidance System (TCAS)

Responsible Division

ASA-100, Robert Valone

Purpose

Develop and demonstrate a viable ground-independent airborne collision avoidance capability. The aviation community will be provided with the standards and certification guidance materials required for implementation of this capability in support of the National Airspace System Facilities and Equipment Plan goal of independent air traffic control (ATC) backup.

Approach

The TCAS concept comprises three basic system components. TCAS I is a relatively simple proximity warning system with the ability to indicate the relative position of an intruder on an appropriate cockpit display. The traffic advisory indicates the range, bearing, and, if Mode C equipped, the relative altitude of the intruder aircraft. TCAS II provides traffic and resolution advisories that recommend collision avoidance maneuvers for purposes of ensuring safe separation from aircraft on collision or near-collision courses. The resolution advisories that TCAS II displays to flight crews are in the vertical plane (e.g., CLIMB, DO NOT DESCEND). TCAS III equipment is designed to generate traffic and resolution advisories in both the vertical and horizontal planes (e.g., TURN RIGHT/TURN LEFT).

The development of TCAS logic is divided into two principal areas: surveillance techniques, whereby TCAS can accurately locate and track nearby aircraft, and collision avoidance algorithms, which effectively distinguish between aircraft on near-collision courses and those that are adequately separated and generate resolution advisories to achieve safe separation. Surveillance techniques are developed using engineering analysis and simulation, followed by in-flight measurements for verification. Collision avoidance algorithms are tested through use of computer simulations of various near-collision and planned aircraft encounters.

The installation of TCAS units on in-service aircraft requires the development of airworthiness criteria for such installations and certification guidance for meeting these criteria. In addition, flight procedures must be written for the associated operational use of the TCAS equipment.

The development of airworthiness criteria generally begins with the convening of a Special Committee of the Radio Technical Commission for Aeronautics (RTCA). This committee provides minimum operational performance standards (MOPS) that describe the functions and levels of performance required of TCAS equipment and incorporate the basic surveillance and collision avoidance algorithm requirements.

RTCA has completed the MOPS for TCAS I, and the FAA is now planning to conduct a limited installation program (LIP). Six preproduction units will be fabricated, tested, installed, and certified on several small commuter aircraft and evaluated under routine operating conditions during a 1-year period.

TCAS II is currently in the in-service evaluation phase. In FY 1989, the LIP involving two airlines will be completed, including evaluation of prototype units on board two Northwest Airlines MD-80s and a United Airlines B737 and DC8 aircraft. A demonstration of TCAS II operation is being planned on commuter aircraft following the completion of the airline evaluation.

TCAS III bearing performance monitoring software and surveillance and collision avoidance system (CAS) logic development will be completed in FY 1989. In FY 1990, final drafts of the TCAS III MOPS and safety study will be completed. The FAA is planning to conduct a LIP similar to that performed for TCAS II, including a 6-month operational evaluation by airlines.

Products

- TCAS I
  - Certification guidance for the LIP.
  - LIP evaluation reports.
- TCAS II
  - Piedmont evaluation reports.
  - LIP evaluation reports.
  - Certification guidance for commuter demonstration.
  - Commuter demonstration reports.
- TCAS III
  - MOPS adopted by RTCA.
  - Reports on surveillance and CAS logic development.
  - Certification guidance for the LIP.
  - LIP evaluation reports.

Recent Accomplishments

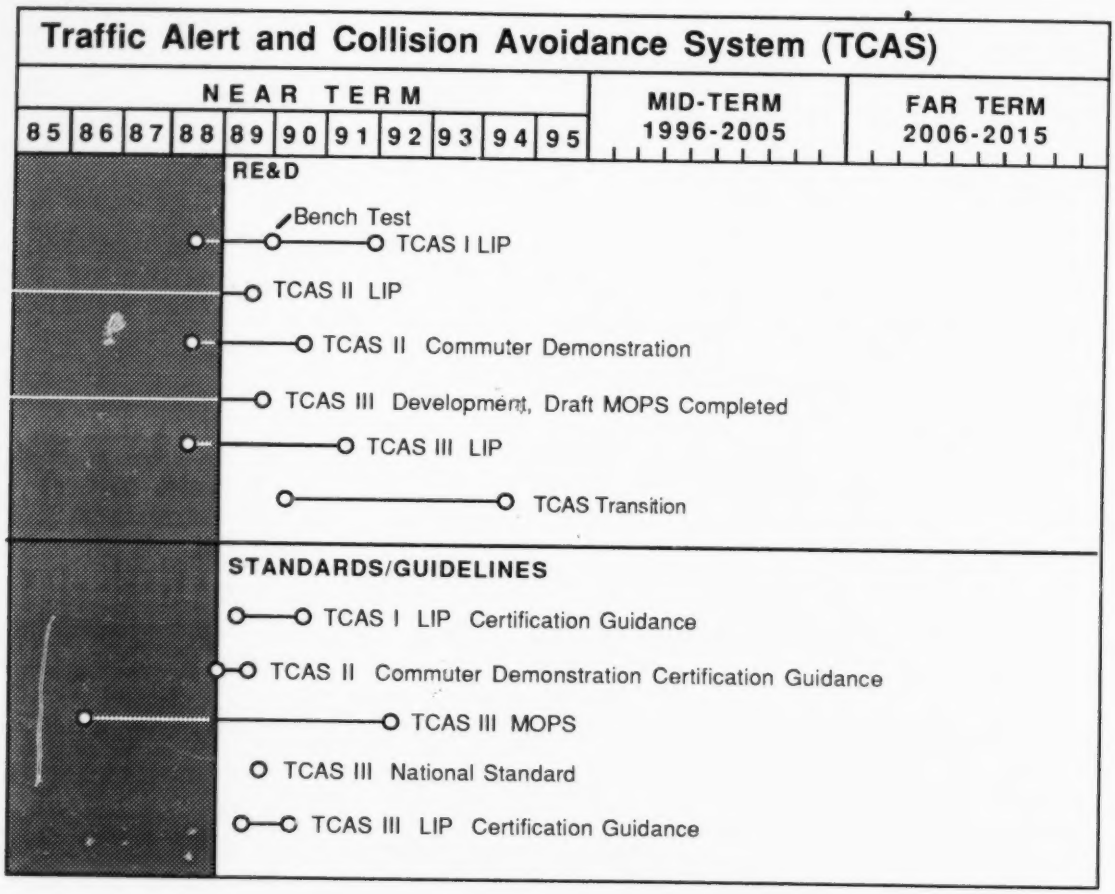
- TCAS I MOPS adopted by RTCA.
- TCAS II Piedmont evaluation completed.
- TCAS II Northwest LIP evaluation started.
- TCAS II Northwest LIP evaluation begun.

- TCAS II Advisory Circular published.
- TCAS III CAS logic version 2.1 flight testing completed.

Related Projects/Activities

None.

Project 9.1



9.2 Airborne Windshear Detection and Avoidance

Responsible Division

ADS-200, William F. White

Purpose

Reduce aircraft exposure to severe low-altitude windshear by using airborne detection, warning, and avoidance.

Approach

Develop the requirements for airborne windshear systems that will enable the flight crew to reliably detect and avoid hazardous windshear along the intended flight path. There are three project elements that support the effort: hazard definition, sensor assessment, and flight management and integration. The project is being accomplished through a cooperative effort with the National Aeronautics and Space Administration. National resources and facilities are involved, including the aircraft landing dynamics facility, aircraft simulation capabilities, the ability to perform four-dimensional mesoscale atmospheric modeling and analyses, and fully instrumented flight test facilities. The technology will be transferred to manufacturers and operators in order to accelerate their development and certification programs. This technology transfer is being accomplished through annual public workshops and joint ventures with manufacturers.

Products

- System requirements for airborne forward-looking windshear sensors, such as lidar, radar, and infrared.
- Report on criteria for alerting and warning.
- Study of cockpit-related human factors.
- Study of heavy rain effects on aerodynamic performance; airmass sensor performance; and lidar, radar, and infrared performance.

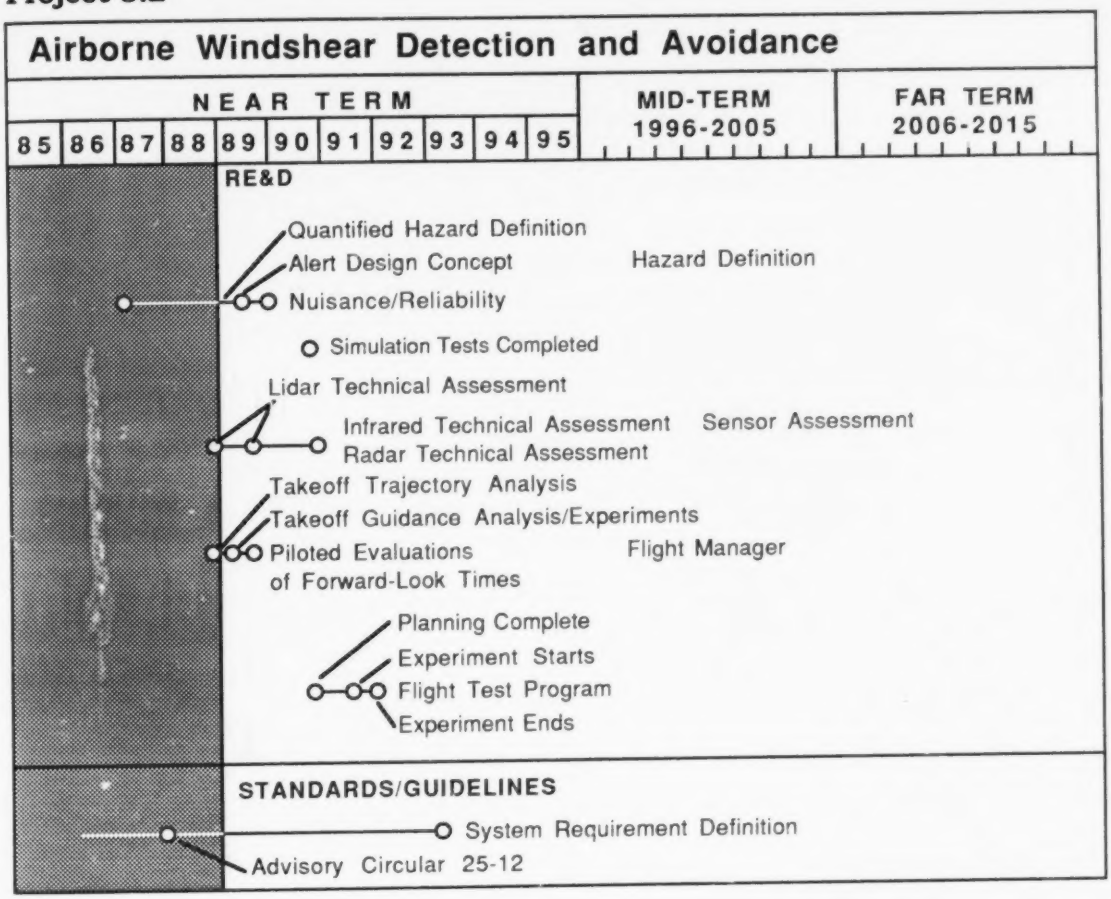
Recent Accomplishments

- Quantitative definition of the atmospheric hazard posed to aircraft performance that applies to all windshear sensors.
- Airborne lidar technology and concept assessment.
- Piloted simulation evaluations of forward-look time requirements.
- Terminal area atmospheric math model developed.
- Test facility completed for full-scale, heavy rain effects.
- Simulation tests of integrated airborne windshear avoidance system concept.

Related Projects/Activities

- Windshear training aid.
- Low-Level Windshear Alert System Enhancements.
- Terminal Doppler Weather Radar (TDWR).
- ATC Weather Information Transfer.

Project 9.2


Airborne Windshear Detection and Avoidance
NEAR TERM
85 86 87 88 89 90 91 92 93 94 95
MID-TERM 1996-2005
FAR TERM 2006-2015
RE&D
Quantified Hazard Definition
Alert Design Concept
Hazard Definition
Nuisance/Reliability
Simulation Tests Completed
Lidar Technical Assessment
Infrared Technical Assessment
Sensor Assessment
Radar Technical Assessment
Takeoff Trajectory Analysis
Takeoff Guidance Analysis/Experiments
Piloted Evaluations of Forward-Look Times
Flight Manager
Planning Complete
Experiment Starts
Flight Test Program
Experiment Ends
STANDARDS/GUIDELINES
System Requirement Definition
Advisory Circular 25-12

9.3 Rotorcraft/Power Lift Vehicles Obstruction Avoidance

Responsible Division

ADS-200, William F. White

Purpose

Develop the technology and methodology to detect and avoid obstructions during rotorcraft/power lift vehicle operations at low altitudes.

Approach

Analyze accidents to identify common scenarios which have a high risk of collision. Define appropriate procedures and technologies which could reduce collision risks. This will include a consideration of cockpit workload and its effect on collisions and means of reducing such workload where necessary.

Products

- Technical reports on short-term procedural changes expected to improve avoidance of obstacle strikes.
- Identification of candidate equipment for development and evaluation.
- Definitions of workload in the very low altitude environment.

Recent Accomplishments

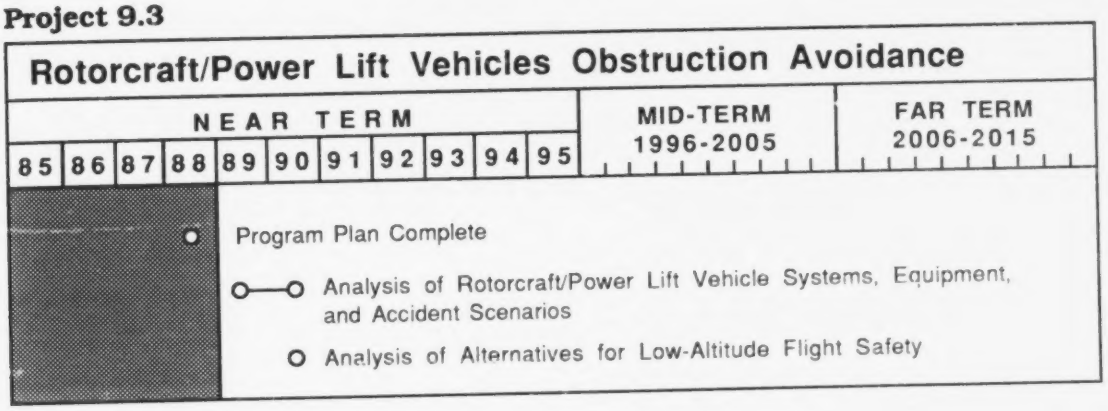
- Program plan.

Related Projects/Activities

- Rotorcraft/Power Lift Vehicles IFR Operations Evaluation.
- Rotorcraft/Power Lift Vehicles Display and Control Studies.
- Heliport/Vertiport Design and Planning.

Project 9.3

Rotorcraft/Power Lift Vehicles Obstruction Avoidance



10. Airports

The RE&D projects described in this chapter are concerned largely with physical and environmental aspects of airports such that airport facilities and services can continue to meet the needs of air commerce. Airports projects are primarily directed at the FAA major missions of capacity and safety, although the efficient movement of people, baggage, and freight is also important. Rapid changes in the demand for airport services are being introduced by hub locations and new markets, placing great stress on individual airport capabilities. In recognition of the growing capacity problem, airport development was identified as an Impact 88 initiative, and airports are discussed as an area of special RE&D emphasis in this plan (Volume I, Section 4.3.1).

In response to capacity issues, the FAA is accelerating its efforts to develop airport standards and guidelines and has initiated four new projects in the airports area. The projects included in this area are:

Airports

10.1	Pavement Strength, Durability, and Repair
10.2	Airport Safety
10.3	Airport Capacity and Delay
10.4	Airport Capacity Task Force Studies
10.5*	Airport Capacity Enhancement Planning
10.6*	Terminal/Landside Traffic Modeling
10.7*	Heliport/Vertiport Design and Planning
10.8	Environmental Activities

* New Projects FY 1987 and FY 1988

Efforts in airport standards and guidelines address the design, construction, operation, and maintenance of airports. Specific considerations are: airport layout and geometrics; pavements, terminal buildings, and heliports; firefighting and rescue equipment; runway friction measurements; snow and ice control equipment and methods; airport surface lighting and visual guidance aids; bird and wildlife control; runway surface contamination detection and removal; and assessment of the environmental impacts of aircraft operations. Landside capacity is also addressed through such considerations as roadway circulation systems, pedestrian circulation systems, parking, mass transit access, and curbside vehicle and passenger exchange points.

The airport RE&D activity must anticipate future airport requirements arising from increased demand and new aircraft types. Aeronautical technology is expected to make major advances in the coming decades. Technology forecasts by the National Aeronautics and Space Administration (NASA), the National Research Council, the joint government/industry task force, and aviation industry organizations indicate that the types of aircraft in use today may be technologically superseded by the end of this century. Advanced-configuration subsonic

and supersonic aircraft for passenger and freight applications, short takeoff and landing (STOL) and vertical takeoff and landing (VTOL) aircraft, advanced general aviation aircraft, rotorcraft, and tiltrotor aircraft will be operating in the early part of the next century. Aircraft serving international passenger and freight markets are likely to be bigger and heavier than those currently in use. The operation of these and advanced supersonic aircraft, although limited to a small number of airports, will require extensive modifications to airport standards to include provisions for wider runways and taxiways, enlarged aprons, and suitably redesigned gates. The strength and durability of the pavement will have to be improved to accommodate landing gear with more wheels, in addition to tire pressures, loads, and load repetitions higher than those currently encountered.

Tiltrotor and VTOL aircraft will require improved pavement materials with higher resistance to heat and blast. The effects of heavier aircraft on rooftops and in urban areas will require a better understanding of the impact of downwash. New aircraft will also introduce new fuels and materials, while crash, fire, and rescue systems will require new techniques for effectively extinguishing fires involving these aircraft. Environmental consequences of operating new types of aircraft in urban areas will require careful consideration.

Since projections of new airports involve considerable uncertainty, the majority of the anticipated increase in demand for airport capacity must be accommodated through the expansion and better utilization of existing airports. As a result, it will be necessary to reduce runway occupancy time, provide efficient runway exits, improve overall airport system design, improve terminal and landside traffic, and construct additional runways (for example, short runways to accommodate commuter aircraft and rotorcraft landing areas). The short runways will provide additional fixed-wing capacity at those airports now being used by helicopters merely for lack of a more appropriate landing area.

The need to integrate the operation of diverse vehicle types and improve the safety of ground operations in conditions of reduced visibility will also require improved lighting and visual guidance systems. Moreover, a high priority is assigned to the development of new techniques for detecting and removing runway contaminants such as ice, snow, slush, and rubber deposits, to improve the safety of all-weather operations. Tasks related to wildlife control, land use, and wildlife management will also be pursued in an effort to reduce airport wildlife hazards to aircraft.

The new airports projects focus on strengthening airport planning and design with products that provide more direct technical assistance to airports for meeting capacity demands. Capacity-enhancing projects and technologies will be evaluated on an ongoing basis and incorporated into an annual Airport Capacity Enhancement Plan. Airport efforts will also include the development of a model for use in the design of airport passenger terminals, standards for heliport and civil tiltrotor landing areas, and a planning guide for tiltrotor landing areas or "vertiports." In addition, the new initiatives in systems modeling (Chapter 2) include means for examining and predicting the impact of systemwide operational changes on terminal airspace and airport capacity.

10.1 Pavement Strength, Durability, and Repair

Responsible Division

ADS-200, William F. White

Purpose

Develop economical airport pavement designs and design guidelines that will provide increased strength and durability and reduced requirements for repair.

Approach

Develop new cost-effective analyses, design and construction techniques, and methods for enhancing the strength and durability of geotechnical materials suitable for use as airport pavements. These materials must be sufficiently strong to sustain repeated wheel loading, must be insensitive to changes in temperature and moisture, and must also be free from susceptibility to frost damage and thaw weakening. Currently, specific additives such as petroleum products, coal tar, portland cement, lime, fly ash, granulated rubber from old tires, and sulphur are being used as stabilizers in geotechnical materials. Certain polymers and resins have also been used on an experimental basis on a limited scale.

In FY 1991, new polymer binders will be evaluated for their ability to reduce cracking, promote rapid repair, decrease maintenance costs, and provide even greater strength and durability to pavement components. These binders must be cost-effective when produced in quantity, environmentally acceptable for use in construction, and energy-efficient in production and use. Mix designs should be easily formulated, and the mixed materials should be easy to handle, should cure quickly, and should be ready for aircraft traffic in a short period of time. Guidelines will also be developed for storing, hauling, mixing, placing, and compacting these new materials to form smooth, durable surfaces.

Acceptance criteria and payment adjustment factors being developed under the project will be applied on new projects for field validation purposes. This project will also investigate the use of reinforced aggregate and marginal materials for airport pavements. For promising materials, full-scale test sections will be constructed, instrumented, and tested under normal operations at airports.

In parallel with the development of better pavement materials, improved analytical techniques for pavement design and evaluation will be formulated. These techniques will provide an accurate assessment of pavement response to different aircraft wheel loadings and will model the effects of variations in temperature and moisture on new pavement joint configurations. These analytical techniques will be programmed for computation on personal computers, and the programs will be streamlined and improved as much as possible to decrease computation times. Design methods for pavements in cold regions will be developed to minimize the effects of frost heave and thaw weakening. Pavement designs based on these new analytical techniques will be compared to conventional designs, and the most promising technique will be used to design the test sections discussed above.

This project will develop improved methods of nondestructive structural testing, evaluation, and rehabilitation. Specific activities will include remote sensing techniques to detect delaminated areas, subsurface voids, sinkholes, cracks, layer separations, and density and moisture variations. Ground-penetrating radar, infrared imagery, ultrasonics, resistivity testing, and microseismic techniques will all be evaluated for remote sensing applications. New methods will be developed for obtaining an accurate and reliable estimate of the remaining life of pavements.

Pavements require periodic repair to maintain an acceptable level of performance. Repair procedures will be developed for the new pavement materials and for pavements for cold regions. The adhesion of repair materials to existing pavements will be investigated, and faster curing repair materials will be identified to provide longer lasting repair. Improved crack and joint repair, surface and subsurface drainage, slab replacement, crack retardation, and undersealing materials will also be developed. The use of improved pavement coatings, sealants, and man-made fabrics in pavement repair will be explored.

New quality-control acceptance criteria will be completed in FY 1990 and made available to appropriate airport officials. Also in FY 1990, the study on nondestructive testing (NDT) methodology and layered elastic design will be completed. Work will continue on the evaluation of a new drainage system in FY 1990 (plastic core and wrap) and will be completed in FY 1991. New efforts will be evaluated to develop criteria for materials such as polypropylene fibers and geotextiles in airport pavements.

Products

- Technical reports and procedures manuals.
- Design and analysis software and user guides.
- Test methods and NDT methodology.
- Guidelines and criteria for pavement design, construction, and maintenance.

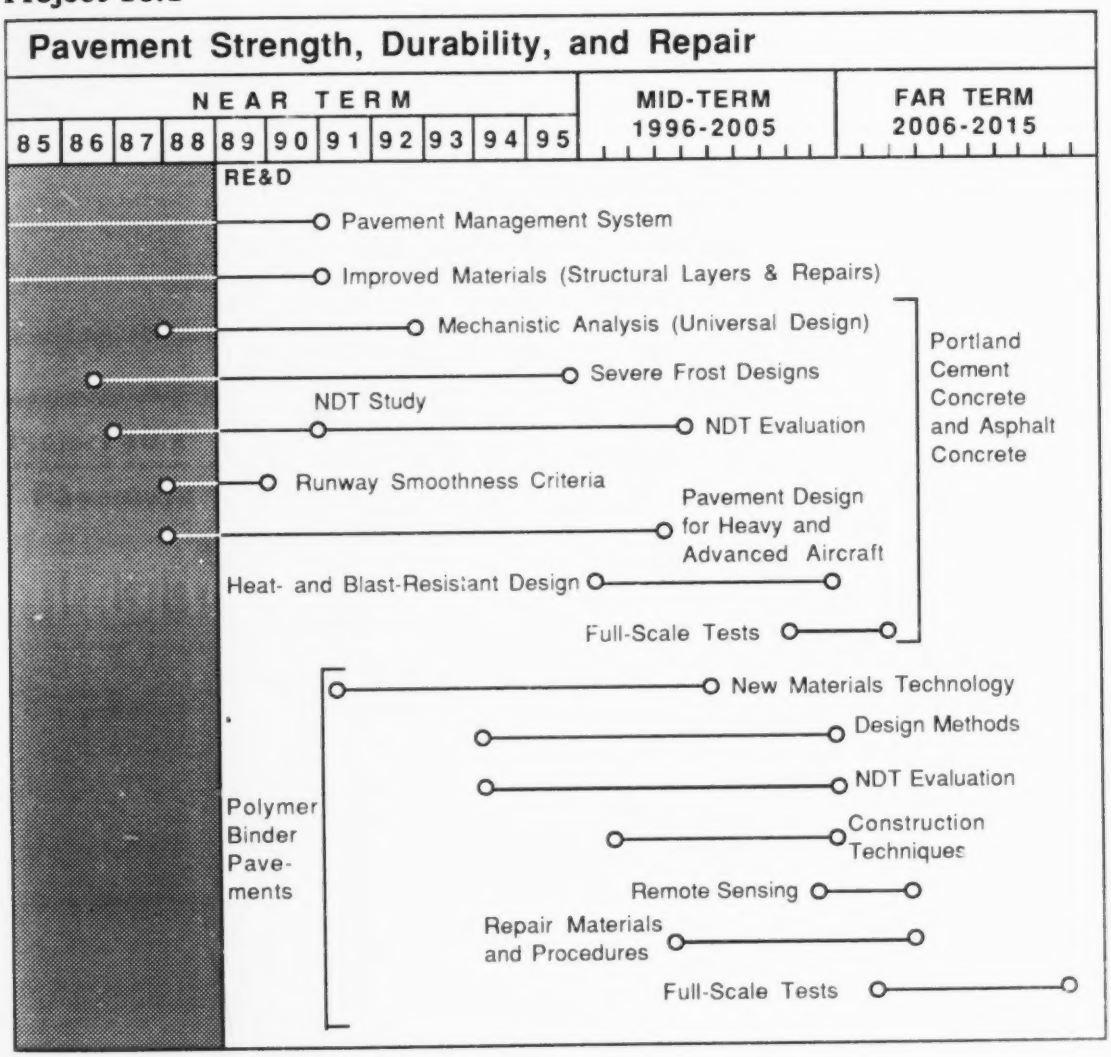
Recent Accomplishments

- Report on airport pavement evaluation using NDT and overlay design.
- Report on update of overlay thickness criteria for rigid pavements.
- Report on investigation of subgrade strength and overlay compatibility.
- Report on crack and seal procedures for airport pavements.
- Report on recycling of portland cement concrete airport pavements -- an experimental investigation.
- Report on criteria for coal-tar seal coats on airport pavements.
- Report on consequence of layer separation on pavement performance.
- Report on pressure meter moduli for airport pavement design and evaluation.

Related Projects/Activities

- Airport Safety.
- Airport Capacity and Delay.

Project 10.1



10.2 Airport Safety

Responsible Division

ADS-200, William F. White

Purpose

Continuously improve aircraft safety and airport capacity by providing enhanced visibility, wildlife control, improved rescue and firefighting (RFF), refueling systems, and improved high-speed runway exits.

Approach

Specific study areas include lighting and visual aids, soft ground deceleration, wildlife control, firefighting equipment and agents, fuel-tank leak sensing, and aircraft braking and turning characteristics.

Improved lighting and visual aids will be developed for the landing environment down to very low visibility conditions. These aids will include improved visual signs and markings, distance-to-go markers, and other advanced systems for controlling aircraft. Lighting and visual aids unique to STOL and VTOL aircraft facilities will also be developed. New concepts for lighting and its energy sources, as well as self-contained systems requiring little or no maintenance, will be investigated. In FY 1989, work will continue to establish standards for visual aids in different visibility conditions. This effort will be completed in FY 1991 with the development of standards for signs and lights for taxiways, taxiway intersections, and runway exits.

The use of gravel, sand, foam, and other soft ground materials will be evaluated for safely decelerating aircraft in runway overrun areas, and appropriate design criteria for such decelerating systems will be established.

The presence of wildlife, such as birds and large mammals, creates potentially unsafe conditions; such wildlife must be kept away from aircraft. Bird reaction to approaching aircraft will be evaluated to determine scare response stimuli and consequent bird reactions. This will assist in the evaluation of different devices such as noise, strobe lights, and other scare tactics. Habitat management techniques and improved land-use management will be evaluated. Real-time warning through the use of ground radar for detecting wildlife will also be investigated. Studies on bird responses to aircraft and low frequency sound will be completed in FY 1991 with the development of a bird hazard assessment model.

A state-of-the-art study and a manual on current firefighting systems will be prepared. Preliminary laboratory tests previously conducted on advanced aqueous film-forming foams will be continued on compatible complementary chemical agents. Full-scale fire tests will be conducted on promising systems. Work will continue in FY 1990 on the effectiveness of various combinations of firefighting agents. This effort will be completed in FY 1992. In FY 1989, agents for special purposes, such as for magnesium (aircraft wheel) fires, and others with properties to emulsify fuels will continue to be investigated. This work will be completed in

FY 1990. New initiatives in FY 1990 will include the testing and evaluation of hand-held cabin protection devices and new firefighting vehicles. Off-pavement mobility improvements of the firefighting vehicles will be evaluated.

Sensors for detecting fuel leaks from buried tanks will be investigated. These sensors must be accurate and reliable enough to keep leakage to a minimum and prevent the pollution of the underground environment.

Studies on ground friction will be conducted. These studies will address the effects of fire parameters, pavement characteristics, runway profiles, and drainage on aircraft braking and turning forces in an effort to set the limits of the forces.

Products

- Research reports and design criteria.
- Computer programs and user guides.
- Specifications and procedures manuals.
- Lighting standards for airports.
- Friction-measuring devices.
- Devices to scare birds from airports.

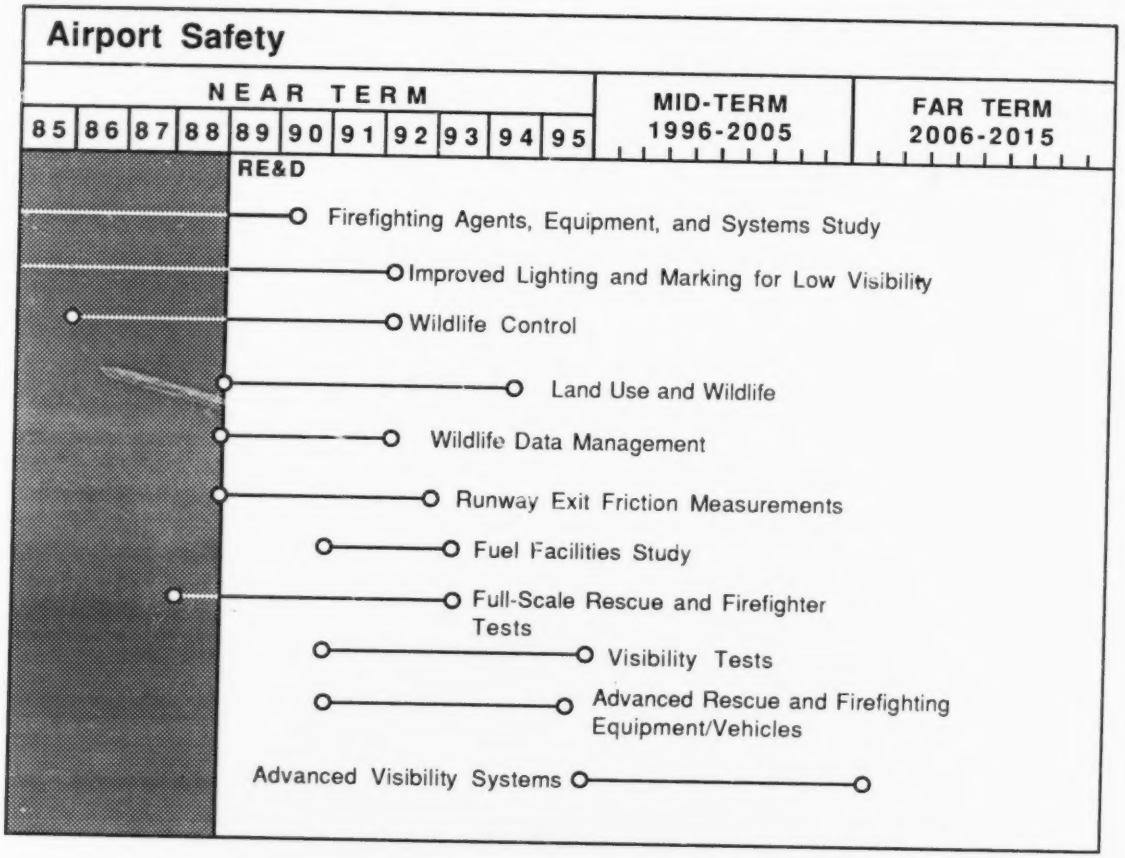
Recent Accomplishments

- All tests comparing B-737 and B-727 with runway friction-measuring systems conducted. Draft report completed by NASA.
- Report on study of improved rubber removal from porous friction course published.

Related Projects/Activities

- Pavement Strength, Durability, and Repair.
- Airport Capacity and Delay.

Project 10.2


Airport Safety
NEAR TERM
85 86 87 88 89 90 91 92 93 94 95
MID-TERM
1996-2005
FAR TERM
2006-2015
RE&D
Firefighting Agents, Equipment, and Systems Study
Improved Lighting and Marking for Low Visibility
Wildlife Control
Land Use and Wildlife
Wildlife Data Management
Runway Exit Friction Measurements
Fuel Facilities Study
Full-Scale Rescue and Firefighter Tests
Visibility Tests
Advanced Rescue and Firefighting Equipment/Vehicles
Advanced Visibility Systems

10.3 Airport Capacity and Delay

Responsible Division

ADS-200, William F. White

Purpose

Obtain increases in airport capacity and decreases in delays through:

- Improved airport/airside and terminal/landside designs and configurations.
- Efficient ground movement for current and future aircraft.
- Improved sensing and removal of snow and ice.
- Improved aircraft decelerating systems in overrun areas.
- Improved landside vehicular and pedestrian circulation and access systems.

Approach

This project will provide concepts, designs, and systems that will increase airport capacity and reduce delays. New and improved concepts and designs will be formulated for reducing runway occupancy time (ROT). Runway exits with low exit angles, varying radii, and wide throats will be included. These concepts and designs will be tested in aircraft simulators for pilot acceptability, and some will be demonstrated at specific airports in the Airport/MLS Demonstration Program. Current taxiway geometries and new alternative designs, including multiple lane and exit taxiways and runway crossovers, will be evaluated in airfield simulation models for improved traffic flow.

New analytical tools and improved design criteria will be developed and existing airfield simulation models enhanced. Improved models will be used to analyze upgraded airport designs and configurations that will accommodate all conventional takeoff and landing aircraft, as well as integrated facilities for helicopters, STOL, and VTOL aircraft in the airport complexes (e.g., off-runway areas for rotorcraft arrivals and departures). Several specific configurations of runways, taxiways, and aprons will be evaluated as regards the distances and times required for ground operations. Facilities for STOL and VTOL aircraft and rotorcraft will then be added to these configurations, and the resulting airport systems will be evaluated for overall operating efficiency. Clearances for new aircraft types; direct taxiing to ramp; and new fillet designs, curves, and apron requirements will be investigated for their potential contribution to improved aircraft and airport compatibility.

Sensors for detecting and measuring the thickness of water, slush, snow, and ice on runways, as well as improved methods of removing these substances, will be evaluated.

Future airport terminals and landside facilities are expected to handle much heavier passenger volumes, and terminals will have provisions for loading and unloading double-decked aircraft. A dynamic computer simulation program for passenger flow, developed in Project 10.6, will be used for evaluating passenger flows in different terminal and landside configurations to see

how these configurations affect airport capacity. The capability of this program will be demonstrated for various terminal and landside designs. The program will also be used to evaluate the interface between the terminal and ground-access modes. This interface includes vehicular access to the terminal curbside, traffic flows around the airport and the terminal, parking, baggage handling, and freight movements (both airfreight and deliveries of supplies). The object of these investigations will be to eliminate access choke points, to facilitate the movement of people and freight, and to enhance the capacity of airport landside facilities.

Products

- Technical reports and advisory circulars.
- Computer programs and user guides.
- Design criteria and guidelines for airports and heliports.
- Test methods and procedures.
- Methods of analysis.

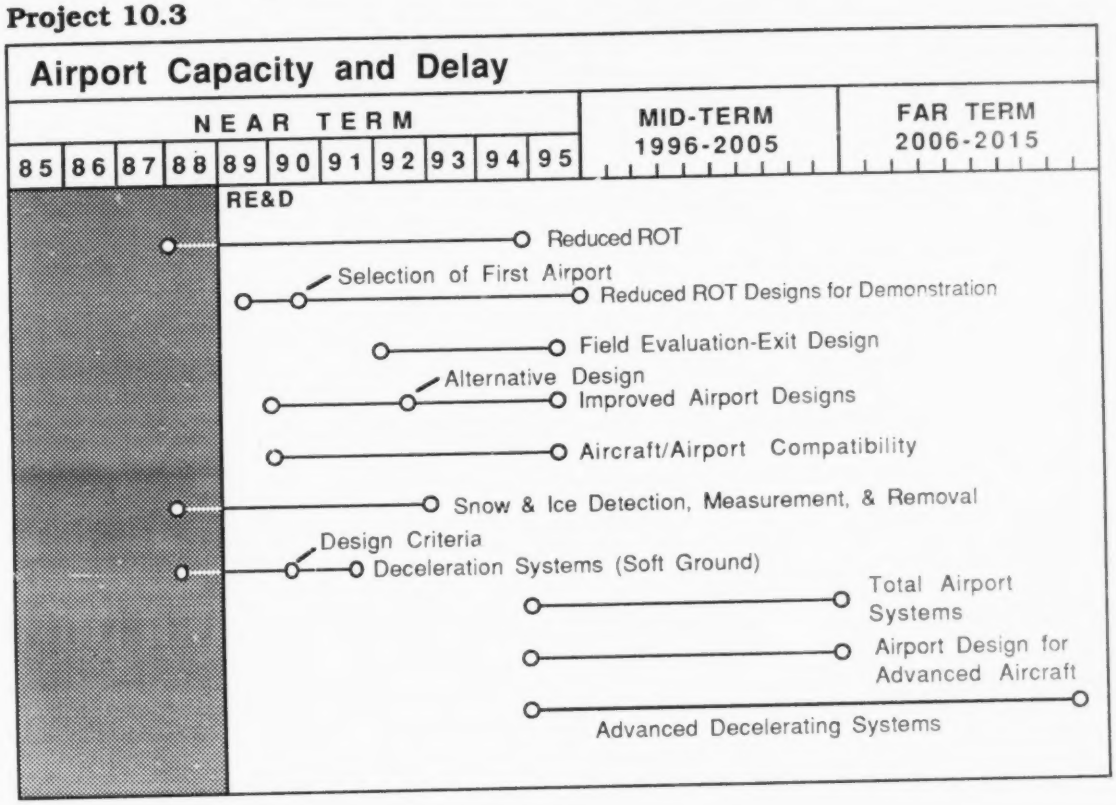
Recent Accomplishments

- Report on soft-ground arresting systems.

Related Projects/Activities

- Airport Capacity Improvements -- Will develop appropriate procedures for operational concepts.
- Pavement Strength, Durability, and Repair.

Project 10.3


Airport Capacity and Delay
NEAR TERM
85 86 87 88 89 90 91 92 93 94 95
MID-TERM 1996-2005
FAR TERM 2006-2015
RE&D
Reduced ROT
Selection of First Airport
Reduced ROT Designs for Demonstration
Field Evaluation-Exit Design
Alternative Design
Improved Airport Designs
Aircraft/Airport Compatibility
Snow & Ice Detection, Measurement, & Removal
Design Criteria
Deceleration Systems (Soft Ground)
Total Airport Systems
Airport Design for Advanced Aircraft
Advanced Decelerating Systems

10.4 Airport Capacity Task Force Studies

Responsible Division

ACP-800, Michael Harrison

Purpose

Establish a forum, sponsored and supported by the FAA, in which airport management, the local FAA, airlines, commuters, industry groups, and airport planning consultants work together to develop technically feasible alternatives for improving airport capacity and reducing delay.

Approach

Establish task forces at airports where the need for capacity improvements is identified. Each task force meets to develop alternatives for improving airport capacity. Alternatives are then evaluated using state-of-the-art simulations. The task forces typically investigate application of new air traffic control procedures and navigational aids, other system installations, airport development, and other prospective capacity improvements. The simulations provide a measure of benefit in terms of hours of delay reduction. Use of simulations in these task force studies allows the FAA to refine modeling techniques while gaining operational benefits through assistance to the task forces.

The task force studies produce a report for the airport recommending a comprehensive program of capacity improvement measures to reduce the level and cost of delay at the airport.

Products

- Action plans incorporating the projects and programs that produce capacity improvements and delay reductions at airports under study.
- Analyzed results of airport capacity.

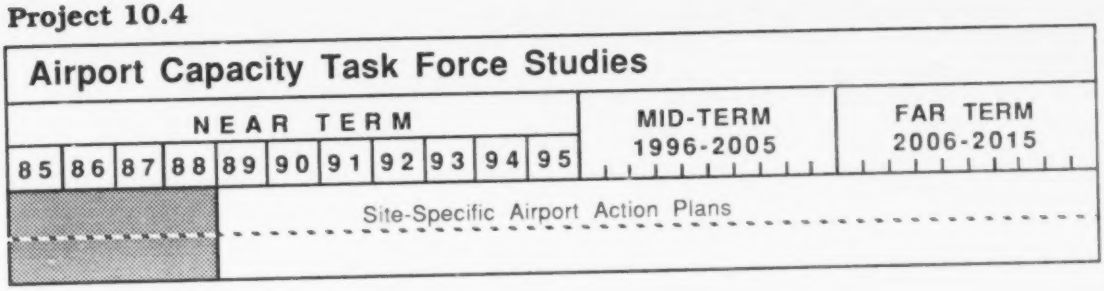
Recent Accomplishments

- Airport capacity task force efforts have been successfully completed in Atlanta, San Francisco, Detroit, and St. Louis. Task forces are in progress at seven other locations. New runways are being considered at Atlanta, Detroit, and St. Louis as a direct result of the airport capacity task force efforts.

Related Projects/Activities

- Airport Capacity Enhancement Planning.

Project 10.4


Airport Capacity Task Force Studies
NEAR TERM
85 86 87 88 89 90 91 92 93 94 95
MID-TERM
1996-2005
FAR TERM
2006-2015
Site-Specific Airport Action Plans

10.5 Airport Capacity Enhancement Planning

Responsible Division

ACP-800, Michael Harrison

Purpose

Identify potential capacity enhancements and their benefits, develop theoretical methods to implement new technology, and report on the status of new airport capacity initiatives.

Approach

Collect and analyze data on the nation's capacity problems, prepare the annual Airport Capacity Enhancement Plan, and survey locations for possible applications of new technology. This effort utilizes the combined resources of the FAA, Transportation Systems Center, and supporting contractors. The planning process is continuous, adapted as necessary to respond to changes in available airport capacity. The Airport Capacity Enhancement Plan is published annually and identifies approaches to improve airport capacity at the nation's 100 largest airports; benefits can also be realized at other airports. The plan focuses attention on needed airport improvements and the status of measures anticipated by the FAA to increase capacity.

Products

- Airport Capacity Enhancement Plan.
- Converging approach procedures.
- Staggered approach procedure development.
- Technical analysis of capacity benefits with new technology or procedures.
- Strategy for RE&D.

Recent Accomplishments

- Airport Capacity Enhancement Plan issued in May 1988.

Related Projects/Activities

- All airport capacity projects.

Project 10.5

Airport Capacity Enhancement Planning

10.6 Terminal/Landside Traffic Modeling

Responsible Division

APP-400, James Mottley

Purpose

Develop a microcomputer-based simulation model with graphic output for use in modeling throughput of airport terminal buildings to alleviate congestion and optimize design.

Approach

This project will develop a simulation model for use in planning airport passenger terminals. The model will analyze pedestrian flow through the terminal building as an aid in estimating space requirements.

A standardized, readily accessible computer simulation program will be a useful tool to architects, engineers, and planners involved in terminal design and expansion. Simulations will aid the airport operator in evaluating terminal improvement options and planning for expansion.

During FY 1989, the FAA will review the computer models currently available for terminal design, including the animated graphics simulation model for airport pedestrian flows prepared by the Canadian Transportation Development Center, the model determining loads of specific passenger terminal elements developed by Stojkovic and Tosic in 1988, and the FAA's airport landside model developed in 1978. While all of these models have useful features, none is fully responsive to FAA requirements. Work will proceed in FY 1990 on Phase 2 -- the development of a documented, microcomputer-based, dynamic terminal building simulation model.

Products

- Public domain software for implementation on a microcomputer.
- User's manual.

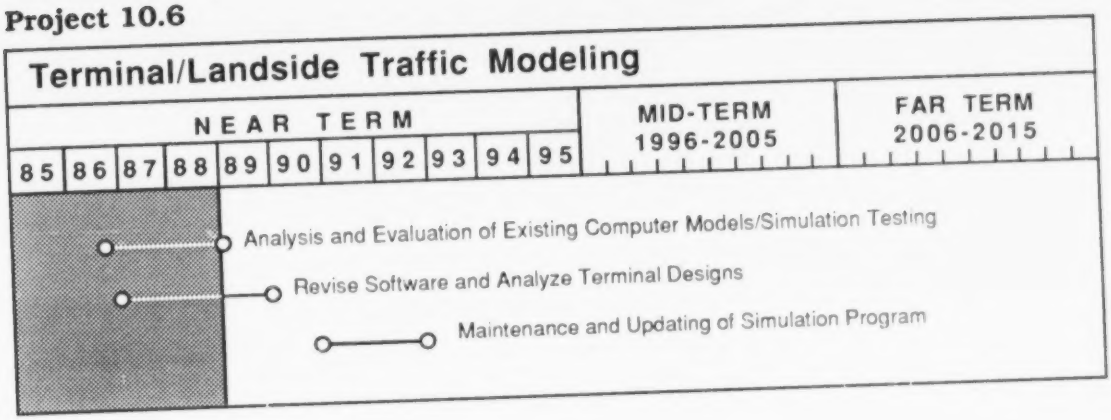
Recent Accomplishments

None - new start.

Related Projects/Activities

None.

Project 10.6


Terminal/Landside Traffic Modeling
NEAR TERM
MID-TERM 1996-2005
FAR TERM 2006-2015
85 86 87 88 89 90 91 92 93 94 95
Analysis and Evaluation of Existing Computer Models/Simulation Testing
Revise Software and Analyze Terminal Designs
Maintenance and Updating of Simulation Program

10.7 Heliport/Vertiport Design and Planning

Responsible Division

ADS-200, William F. White

Purpose

Develop design standards and planning guidelines for heliports and vertiports. Rotorcraft, including the civil tiltrotor, will bring more convenient transportation to a larger number of persons if a system of heliports is available to support the anticipated operations.

Approach

- Develop vertiport design guidelines in cooperation with an FAA/industry working group.
- Develop enhancements to the existing FAA heliport advisory circular.
- Develop an advisory circular for heliport/vertiport system planning based on previously published technical reports.

Products

- Heliport design advisory circular enhancements.
- Vertiport design advisory circular.
- Heliport system planning advisory circular.

Recent Accomplishments

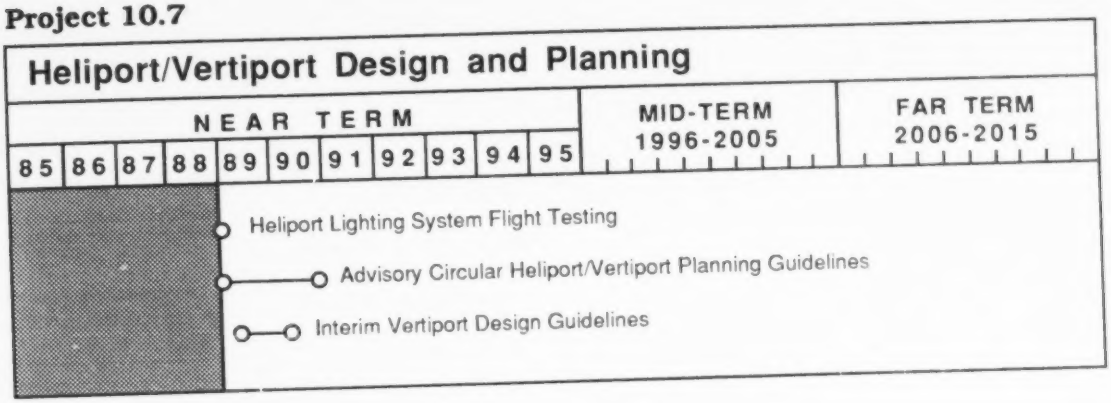
- Heliport design advisory circular.
- Heliport system planning guidelines.
- Heliport automated weather observing system siting criteria.

Related Projects/Activities

- Rotorcraft/Power Lift Vehicles IFR Operations Evaluation.
- Rotorcraft/Power Lift Vehicles Obstruction Avoidance.

Project 10.7

Heliport/Vertiport Design and Planning


NEAR TERM
MID-TERM 1996-2005
FAR TERM 2006-2015
85 86 87 88 89 90 91 92 93 94 95
Heliport Lighting System Flight Testing
Advisory Circular Heliport/Vertiport Planning Guidelines
Interim Vertiport Design Guidelines

10.8 Environmental Activities

Responsible Division

AEE-1, James Densmore

Purpose

Minimize environmental constraints on the growth of the national aviation system, especially airport capacity, through development of the methods, technology, and expertise needed to mitigate or control the environmental impacts of such growth. Develop accurate means for assessing the environmental impacts of aircraft operations and reduce these impacts through improved technology and community standards.

Approach

Aircraft noise in the vicinity of airports has been reduced over the years through the use of new generation aircraft, more stringent certification standards, and effective noise-abatement operating procedures. Emission regulations have also been placed on aircraft engines. These efforts will continue so that the aviation community and the general public will have the most cost-effective and efficient aviation system, with a minimum of environmental effects.

New computer modeling techniques are being developed to assess the effects of local and national capacity constraints proposed for environmental reasons. These models will be used to analyze the cost benefits of the noise versus capacity trade-offs available to the FAA and local authorities.

Helicopter noise-reduction programs will continue to be pursued jointly with NASA, the Department of Defense (DoD), and industry. The computer model database on civil helicopter noise, used as a basis for noise standards, will be expanded to include advanced design, power lift vehicles, such as the tiltrotor. Land-use compatibility criteria for heliports and vertiports will continue to be refined.

The noise and air-quality impacts of emerging new aircraft concepts, such as high-speed civil transport and advanced technology engines, are being followed, and appropriate studies are being conducted. The effects of noise from near and distant operations are also being examined.

Noise compatibility programs of airport sponsors will be reviewed. Improved guidelines for appropriate land use and building construction in airport environs will be developed, and alternative noise-control strategies will be examined from technical, safety, and economic perspectives. Computer modeling of noise and gaseous emissions is being improved to provide better predictive tools for national planning.

The ways in which aircraft engine emissions degrade air quality around airports and in the upper atmosphere will be examined. The Federal Aviation Regulations will be revised to reflect current Environmental Protection Agency (EPA) standards on engine emissions. Finally, a computer model for the assessment of aircraft and airport emissions, developed

jointly with the U.S. Air Force for use at both civil and military airports, has been completed and submitted for EPA and user acceptance as a baseline model.

Products

- Reports on the prediction and assessment of noise impacts of advanced aircraft and engines.
- Improved compatibility criteria for land use near noise-impacted airports and heliports.
- Tiltrotor noise certification standards.
- Refinement of international noise standards.
- Microcomputer pollution model for airports.
- Microcomputer noise model for heliports.
- Noise/capacity trade-offs model for examining systemwide impacts of individual airport actions.

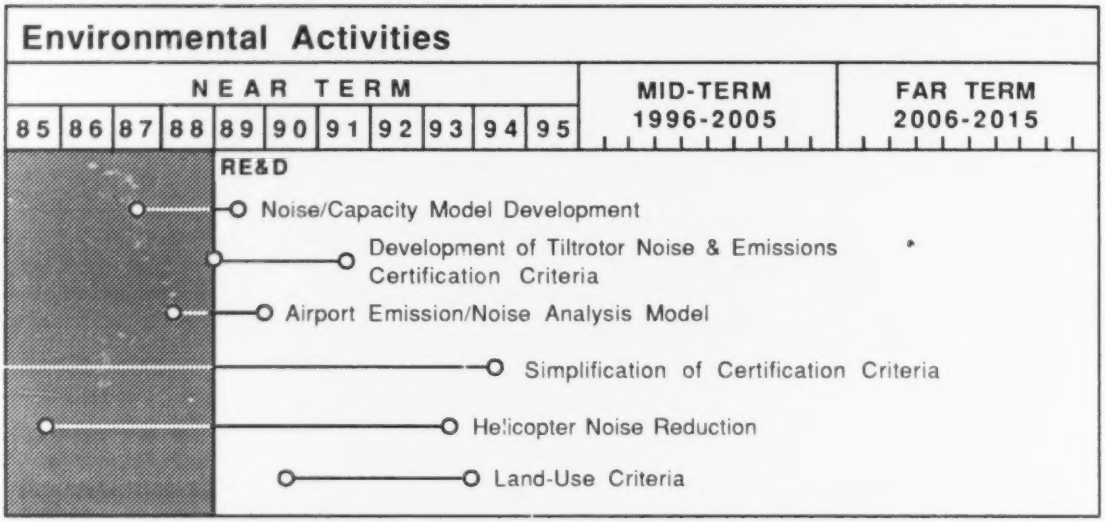
Recent Accomplishments

- Airport noise compatibility rule reissued to include heliports.
- Helicopter noise certification standards issued.
- DoD/FAA/industry cooperative effort on tiltrotor aircraft noise measurements initiated.
- Improved programs released for computing airport and heliport noise contours.
- NASA/FAA propfan acoustic measurement test conducted.
- Part 34 Engine Emissions Rule notice of proposed rulemaking issued and comments received.
- Revised noise standards for small propeller-driven airplanes issued.

Related Projects/Activities

- Aviation fuel conservation -- Will involve simulation of complex airport and airspace traffic conditions and procedures.

Project 10.8


Environmental Activities
NEAR TERM
85 86 87 88 89 90 91 92 93 94 95
MID-TERM
1996-2005
FAR TERM
2006-2015
RE&D
Noise/Capacity Model Development
Development of Tiltrotor Noise & Emissions Certification Criteria
Airport Emission/Noise Analysis Model
Simplification of Certification Criteria
Helicopter Noise Reduction
Land-Use Criteria

11. Aircraft Safety

The goals of the aircraft safety projects, which support the safety mission, are to effectively enhance airworthiness, crashworthiness, and the safety of aircraft operations. At the same time, the program seeks to maintain and improve aircraft and passenger safety without imposing unnecessary constraints on the aviation industry. Currently, there are nine RE&D projects in the area of aircraft safety:

Airworthiness	
11.3	Propulsion and Fuel Systems
11.8	Aging Aircraft
Crashworthiness	
11.1	Aircraft Systems Fire Safety
11.2	Aircraft Crashworthiness/Structural Airworthiness
Aircraft Operations	
11.4	Flight Safety/Atmospheric Hazards
11.5	Rotorcraft Simulator Standards
11.6	Rotorcraft/Power Lift Vehicles Display and Control Studies
11.7	Tiltrotor Certification Support
11.9	International Airworthiness Database

The aircraft safety effort addresses maintenance requirements for an aging aircraft fleet, enhancements to the aircraft for crash and post-crash environments, and operational improvements that will enhance the ability of aircraft to operate safely within hazardous flight conditions. Moreover, the program concentrates on new or challenging technologies and designs and emphasizes activities that provide technical data, guidelines, and economic evaluations related to proposed amendments to regulations, certification criteria, and circulars. The aircraft safety projects include the development of data, information, and criteria on aircraft structures, advanced materials, fire safety, aircraft flying qualities and load interactions, software-based digital flight control and avionics systems, fuel and propulsion systems, atmospheric and electrical hazards such as icing and lightning, durability and fatigue problems, and aircraft maintenance and inspection issues.

In some research areas, such as structures, fire safety, and propulsion, the FAA has unique capabilities and facilities. In other research areas, however, the FAA is coordinating its activities with those of the National Aeronautics and Space Administration (NASA), the Department of Defense (DoD), and the aircraft industry. This coordination will ensure the timely development of appropriate regulations and certification criteria so that mature technologies can be introduced in civil aviation without undue delays. Major advances can be expected in several areas of aeronautical technology, such as aerodynamics, propulsion, structures, materials, guidance, navigation, and control.

Airworthiness

Due to the higher average age of the current civil transport fleet, the FAA will undertake a major study of fatigue and other potential problems associated with high-time airframes and engines. In light of recent airworthiness incidents (see Section 4.3.5, Volume I), it is necessary to determine the conditions upon which maintenance actions shall be taken to avoid catastrophic failure of components. A better understanding of the failure mechanisms prevalent in an aging fleet of aircraft is to be established. This will be based on the analysis of the structural integrity of airframes and propulsion systems. More specifically, analyses of fracture and crack propagation; pitting and intergranular corrosion; stress, fatigue, and erosion; and the hardening of materials will be analyzed to determine the conditions under which catastrophic failures of components occur. Once these conditions are established, the frequency of inspections and the requirements for nondestructive inspection techniques will be determined. Improved inspection techniques will be evaluated for their effectiveness.

In addition, new structure technologies are being introduced for aircraft, with mechanisms of failure that are not well understood. Fiber and matrix combinations in composites have resulted in the highest level of complexity in aircraft construction experienced to date. A technology knowledge base addressing materials and system characteristics, manufacturing and fabrication, and airworthiness considerations is required. Such a knowledge base will enable airframe manufacturers and users to achieve the efficiency and performance improvements made possible by advanced materials, without sacrificing the high level of safety required for FAA certification. Future certification of aircraft, which may incorporate a de-icing technique, will also require careful consideration of potential ingestion of shed ice particles and development of new safety criteria.

Advances in propulsion technology over the next several decades will set the stage for the introduction of inducted-fan and super-high-bypass-ratio-fan engines. These engines will involve the use of smart controls, the application of extreme heat-resistant materials, and a better understanding of heat transfer effects.

Lightweight, nonmetallic structures will be used in aircraft engines. Metals will gradually be replaced by ceramics in hot sections. Turbine blade materials will be advanced versions of the present single crystals, with increased dependence on thermal barrier coatings to reduce cooling requirements. The future development of present super alloys will yield a 50 to 100°C improvement in metal temperature capability.

The FAA will study the effects of higher temperatures and pressures of future engines on the aging processes of such critical parts as casings, frames, stators, and seals. It will also evaluate the adequacy of current regulations for foreign object ingestion and for the higher technology engines, which are expected to be more sensitive to disturbances created in the flow passages.

Even with the technology improvements expected, engines must still function satisfactorily in the everyday environment, which frequently involves ingestion of a myriad of foreign objects. Still prime among these are birds, which account for large magnitudes of damage. New technology must be capable of safely withstanding these expected hazards to the same or greater degree than is currently possible.

Crashworthiness

In the crash and post-crash environment, fire safety and passenger survivability are among the most difficult problems; toxic smoke and fuel fires are responsible for the highest number of fatalities.

The near-term focus is to upgrade the state-of-the-art in aircraft fire safety in the post-crash and in-flight fire environments. New concepts will be examined for their effectiveness. Existing systems and design concepts will be reevaluated, and improvements will be explored. Potential problem areas will be investigated to characterize the problem and identify solutions. Onboard water mist suppression and computerized cockpit-crew fire advisory systems are examples of new concepts that will be tested and developed. Improvements in in-flight smoke venting procedures, seat component flammability, detector capabilities, fuselage burnthrough resistance, and Class B cargo compartment design requirements will be explored. Potential problem areas endemic to modern transports, such as hidden in-flight fires, arcing of thin-walled electrical wiring, auxiliary fuselage fuel tanks, and oxygen systems will be studied to identify solutions.

On a longer range basis, the problem of replacement of the Halon extinguishing agents, which are expected to be discontinued because of environmental considerations, will receive considerable attention. In addition, the introduction of alternative fuels in the future, such as liquid hydrogen, will present a number of factors that will have to be investigated to ensure fire safety.

The potential for increases in operating temperatures of future engines has serious ramifications for post-crash fire scenarios. Higher residual temperature metal or ceramic surfaces offer higher probability of fuel-spill ignition in a survivable crash. Steps to mitigate these hazardous effects must be devised, including the ability to cool such surfaces rapidly and efficiently in the event of a crash. Likewise, fuel improvements or modifications to decrease flammability in such cases must be investigated.

In order to make aircraft more efficient, the aviation industry will continue to make use of stronger, lighter weight composite materials. Concern over the impact dynamics of structures made of advanced composite materials will focus on the nonductile or low strain-to-failure characteristics of the basic material. Research will be directed toward ensuring that the structural configuration of advanced composite aircraft will provide passenger protection equivalent to that of the current aluminum airframe.

Aircraft Operations

With the introduction of more low-flight-regime aircraft (rotorcraft and tiltrotor) and new flight control technologies, certification and operating procedures need to be evaluated. The introduction of full-authority, fly-by-wire techniques coupled with the use of digital flight control and augmentation systems for advanced aircraft and rotorcraft present the need for new certification criteria. Flight crew performance with the new cockpit display and control systems will be assessed, and new certification guidelines developed.

In addition, atmospheric hazards which particularly apply to the low-flight-regime environment pose a need for new criteria. Atmospheric icing and lightning characteristics

will be developed. Although icing protection is important for all aircraft, it is particularly important for helicopters and general aviation and commuter aircraft, which are typically operated for extended periods at lower altitudes where icing conditions are more prevalent. Most large aircraft rely on engine bleed air for icing protection. However, future advanced turboprops and other engines, with their small cores, may not be capable of providing the necessary quantities of bleed air. Composite materials, due to their lower thermal conductivity, may also preclude the use of such systems. Different ice protection systems based on entirely new concepts may, therefore, be required for future use.

Ice protection concepts that rely on removing ice (de-icing) rather than preventing ice buildup (anti-icing) can offer significant weight and power savings. Some of these concepts include electro-impulse, electric-expulsive, and piezoelectric systems; advanced cyclic electrothermal systems; microwaves to create a liquid boundary at the ice-aircraft interface; and possible boots for helicopter rotors. Designs will be developed based on improved analyses of the concepts. Because ice will be allowed to build up on both unprotected and protected components before it is removed, advanced analytical methods will be developed for predicting the associated aerodynamic penalties. Emerging fluid-dynamic modeling techniques will be used to predict droplet trajectories, impingement regions, ice growths, and the resulting separated flow.

The impact of atmospheric electricity, electromagnetic interference (EMI), and high-energy radio frequency field (HERF) both on aircraft using composite materials and on structures having complex, highly integrated electronic systems will have to be considered. New simulation and modeling techniques for the interaction of electrical hazards with aircraft will be necessary to handle poorly conducting advanced materials.

Research efforts have been identified to address the potential hazards associated with the emerging technologies as they apply to aircraft electrical and electronic systems. Cooperative international programs have been initiated to validate analytical models by obtaining parametric aircraft lightning-strike data to develop a lightning characteristic model which will define the upper-bound waveform, including initial and subsequent return strokes, and quantitatively reflect the difference in strokes due to such factors as location, altitude, and season. The environmental models will support the enhancement of interaction analysis techniques, lightning protection techniques, and at the final stage, full-scale testing and simulation.

While composite materials in the airframe may offer strength and weight advantages over metals, they also provide electrical power shielding. Because of the significant differences in transient susceptibility and upset resulting from the use of solid-state digital technology in flight-critical systems and the reduced shielding effects of composite materials, there is a definite need to define the transient and upset threats, develop protection concepts, and use testing methods that will validate these systems for safe flight.

Advances in guidance, navigation, and flight control technology will also have a major impact on future aircraft designs. Improved avionics and the integration of aerodynamic, propulsion, and structural controls will provide improved aircraft performance. New structural controls will also yield enhanced flight capabilities and increased aerodynamic stability. Although the benefits of such integrated designs have already been

demonstrated, the interfacing of the pilot with these new flight control systems remains an important topic of investigation.

By the year 2000, ultra-fault-tolerant, high-integrity flight control systems will be available to support virtually any vehicle configuration. These systems will be highly reliable and will have embedded fault reconfiguration capabilities. New methods of certification for these systems will be developed so that they may be verified and validated in a cost-effective manner.

Because of the projected higher load conditions and increased number of landing cycles between tire removals, inspection methods for wheels will also be reviewed. With the higher speed radial tire designs being developed for airplanes, new procedures for the maintenance and inspection of the tire, wheel brake, and landing gear systems will be analyzed. This effort will include studies of advanced inspection equipment and techniques, as well as a review of upgraded holographic tire inspections.

11.1 Aircraft Systems Fire Safety

Responsible Division

ACD-200, Nelson Miller

Purpose

Minimize fire-related injuries and increase survival rates for aircraft occupants during in-flight and post-crash fires.

Approach

The program addresses both in-flight and post-crash fire problems. A number of active and planned projects seek to improve in-flight fire safety. The effectiveness of current emergency smoke-venting procedures has been evaluated, and better measures are under development. Fire safety personnel are studying hidden in-flight fires in lavatories, behind wall panels, and in other inaccessible places, and are conducting full-scale fire tests. Improvements may need to be developed for fire detection and suppression and for fireworthy interior materials in inaccessible areas. Electrical wiring insulation is being studied for vulnerability to tracking failure, which may cause power loss or ignition.

Testing related to in-flight safety will be initiated to develop improved fire safety designs for Class B cargo compartments in combination passenger/freighter airplanes. Oxygen systems and components will be evaluated under various fire scenarios to define potential fire hazards. Aircraft smoke detectors will be tested to develop a definite measure of their performance capability for a matrix of fire scenarios. Control of cabin fire through the decrease in flammability resulting from cabin depressurization will be explored.

In the area of transport aircraft post-crash fire protection, current efforts are limited to improving the burnthrough resistance of an aircraft fuselage to an external fuel fire. However, future efforts will focus more on the post-crash fire problem. In FY 1990, studies will be initiated to examine the effectiveness and practicality of an onboard, water mist fire suppression system. Another study will address problem areas such as accidental in-flight activation and slowing of passenger activation. Fuselage auxiliary fuel tanks will be tested to determine their vulnerability to post-crash and in-flight fires and to minimize or eliminate potential dangers, such as those from flame and smoke penetration through floor vents or from burnthrough of the cabin floor. Finally, tests are planned to examine the need for upgrading the fireworthiness of seat components other than cushions, such as composite structures and trays. In FY 1991, a data package on the flammability characteristics of seat components will be completed.

A technology assessment will address the feasibility of a computer-based cockpit system for aircraft command in emergency situations. The ultimate aim would be to direct the crew on the best course of action during an in-flight fire.

Regulatory initiatives mainly involve standardizing laboratory fire tests to improve the consistency of test results and assisting certification organizations in applying uniform certification practices.

Accident investigations will continue. In the past, these investigations have identified areas for research leading to fire safety advancements, such as heat-resistant evacuation slides and burnthrough-resistant cargo liners.

The primary aircraft fire extinguishing agents, Halon 1301 and 1211, are to be limited under a new Environmental Protection Agency regulation to protect stratospheric ozone. Studies and tests will be conducted to develop the technical guidelines needed to replace the Halons with environmentally acceptable extinguishing agents.

Hypersonic transport fire safety will also be addressed. Issues to be studied will include liquid hydrogen containment, vaporization and ignitability during a survivable crash, and the thermal resistance of materials heated by the hot fuselage skin during flight.

Products

- Full-scale tests of hidden fires.
- Technical data package on hidden fire protection.
- Feasibility of computerized fire management systems.
- Procedures for in-flight smoke venting.
- Improved fuselage burnthrough resistance.
- Reports on electrical wiring flammability.
- Seat component flammability characteristics.
- Aircraft material fire test handbook.
- Training video on heat release test apparatus (Amendment 25-61).
- Full-scale post-crash fire tests of onboard water mist effectiveness.
- Improved Class B cargo compartment design features.
- Auxiliary fuel-tank fire vulnerability tests.

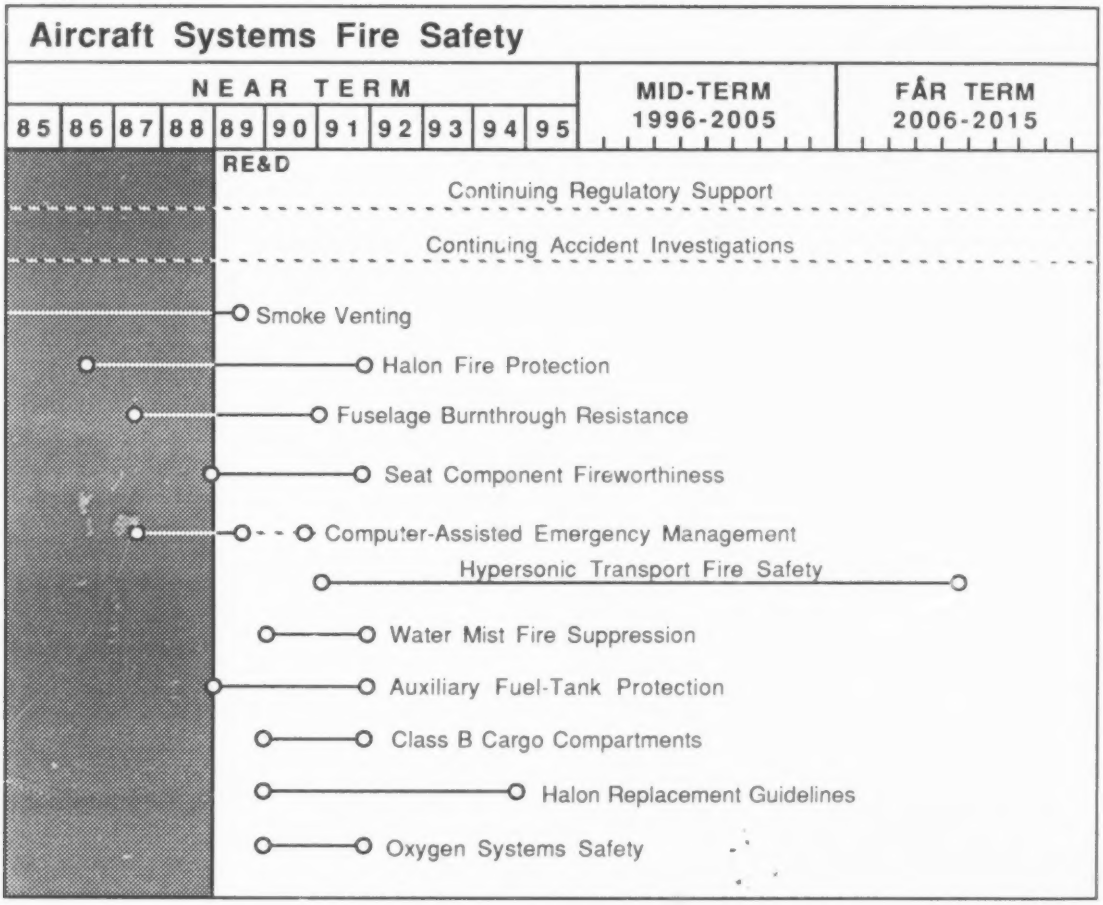
Recent Accomplishments

- Final rule on improved flammability criteria for panels used in interiors of airplanes.
- Report on commuter aircraft fire safety design.
- Report on benefits of protective breathing equipment for passengers.
- Advisory Circular 25.853-1 on flammability requirements for aircraft seat cushions.

Related Projects/Activities

None.

Project 11.1



11.2 Aircraft Crashworthiness/Structural Airworthiness

Responsible Division

ACD-200, Nelson Miller

Purpose

Establish an appropriate technical database for preparing crashworthiness and structural airworthiness criteria, develop test procedures for demonstrating compliance with such criteria, and generate the technical data needed to support the development of certification standards, performance criteria, advisory circulars, and other regulatory material for crashworthiness and structural airworthiness.

Approach

The impact characteristics and crash resistance of metal and composite structures will continue to be investigated as the primary approach to understanding the interactions of the following under dynamic crash loads: the fuselage; the floor and seat structures, including occupant restraint systems; the cabin interior furnishings; and structural fuel containment. Analytical modeling techniques will be employed to evaluate the impact characteristics of various sizes of commuter-type aircraft, as well as occupant emergency evacuation performance.

Various composite structural configurations will be evaluated for both impact resistance and foreign-object damage tolerance. Damage growth characteristics, damage containment techniques, and failure analysis techniques will be investigated, as well as the effects of fatigue and the environment on advanced airframe composites. Engineering and inspection handbooks will be revised as necessary, based on technology growth.

Research efforts will be initiated to determine the effectiveness of advanced nondestructive inspection (NDI) concepts on composite airframe structures.

New radial tire and associated wheel and brake designs will be evaluated to provide performance criteria and operational procedures for maintenance, repair, and inspection.

The use of new digital, fly-by-wire systems, coupled with advanced augmentation systems and control-configured designs, will require investigations of structural airworthiness, flying qualities, and flight load certification issues. New data and information on the technical areas related to pertinent flight testing, certification procedures, and criteria will be provided for the assessment of advanced rotorcraft.

Products

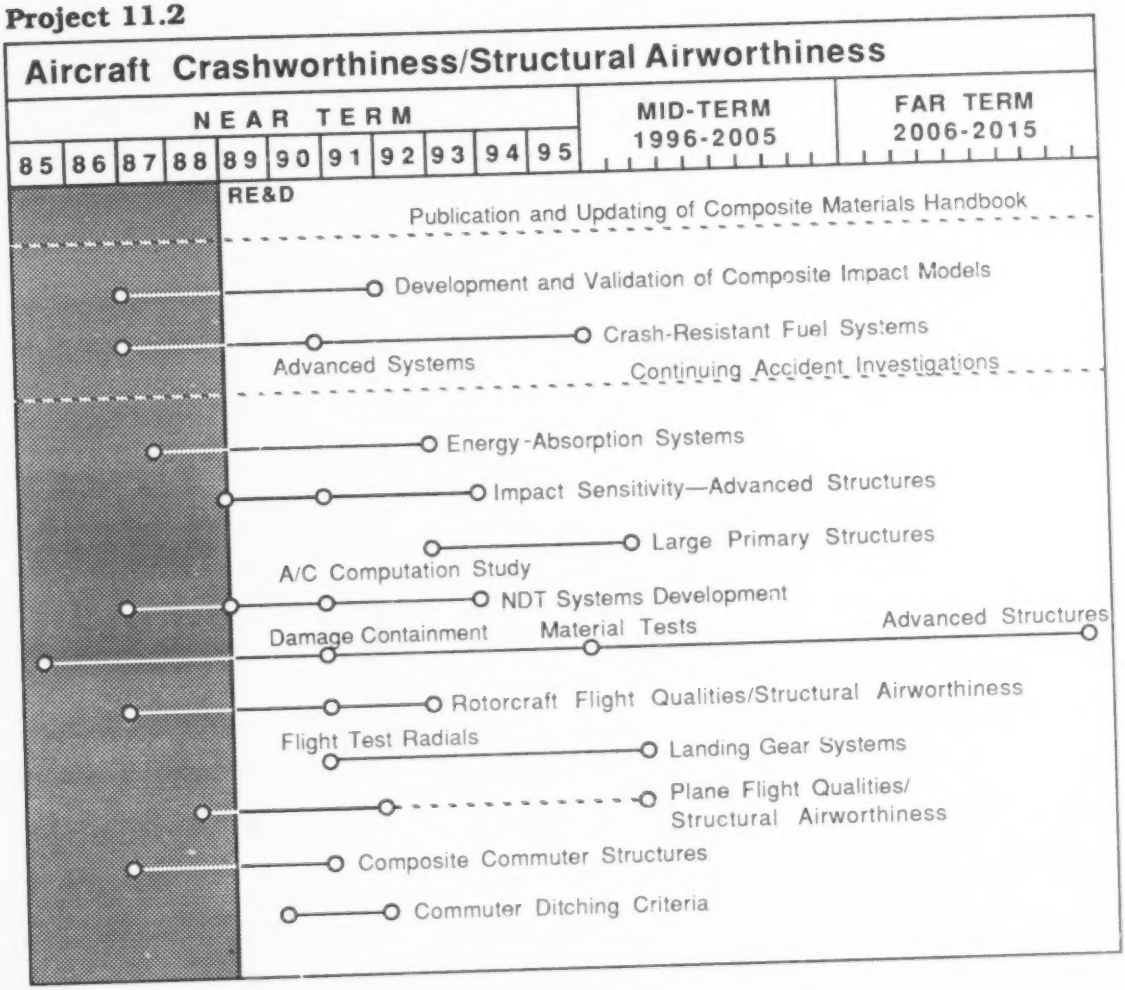
- Supporting data for advisory circulars, standards, and final rules addressing certification criteria for aircraft passenger seating systems.
- Technical data package on criteria for aircraft crash-resistant fuel system design.
- Report on structural response of aircraft constructed of composite materials.

- Data package on the analysis of rotorcraft and general aviation and commuter aircraft crash scenarios.
- Impact damage analysis methods and supporting tests addressing damage sensitivity of advanced composite materials.
- Publications and handbooks for FAA personnel on the characteristics of fiber composites.
- Supporting data for an advisory circular covering the maintenance, repair, and retreading of aircraft tires.
- Supporting data for the development of wheel load spectra for short- and long-haul aircraft operations.
- Guidance material to aid the regions in their certification of aircraft.

Recent Accomplishments

- Reports on survivable crash environments for commuter aircraft.
- Report on fuel containment technology.
- Report on transport airframe impact testing.
- Report on the feasibility of an adhesive bond and composite strength screening system.
- Handbook on engineering, manufacturing, and repair technologies for fiber-reinforced composites in civil aircraft.
- Report on aircraft tire operating profile.
- Draft report completed for supporting final rule of Seat/Restraint Systems for Transport Aircraft.
- Report published on "Degree and Application of Composite Materials Volume II."
- Report on evaluation of wheel performance.

Project 11.2


Aircraft Crashworthiness/Structural Airworthiness
NEAR TERM
85 86 87 88 89 90 91 92 93 94 95
MID-TERM 1996-2005
FAR TERM 2006-2015
RE&D
Publication and Updating of Composite Materials Handbook
Development and Validation of Composite Impact Models
Crash-Resistant Fuel Systems
Advanced Systems
Continuing Accident Investigations
Energy-Absorption Systems
Impact Sensitivity—Advanced Structures
Large Primary Structures
A/C Computation Study
NDT Systems Development
Damage Containment
Material Tests
Advanced Structures
Rotorcraft Flight Qualities/Structural Airworthiness
Flight Test Radials
Landing Gear Systems
Plane Flight Qualities/
Structural Airworthiness
Composite Commuter Structures
Commuter Ditching Criteria

11.3 Propulsion and Fuel Systems

Responsible Division

ACD-200, Nelson Miller

Purpose

Establish airworthiness criteria and related technical materials to ensure the safety, reliability, and durability of powerplants on commercial and general aviation aircraft.

Approach

This project involves the development of criteria, guidelines, and data to support improvements in the certification requirements for turbine and piston engines. In particular, revised criteria, standards, and testing guidelines will be developed relating to the ingestion of foreign objects, such as birds and excessive rain.

The continued occurrence of uncontained turbine engine failures will be examined to establish techniques for prediction and prevention. Concurrently, materials of light weight but high tensile strength will be developed for containing rotor failures.

Current powerplant fire protection guidelines will be evaluated, along with improved fire-resistant materials. Synergistic use of improved fuels and systems to control the initiation and development of post-crash fires will be employed. The use of alternate fuels will be examined, and general aviation powerplant criteria for use of autogas and alcohols will be identified. Criteria for the use of alcohol modifiers for turbine fuels in turboshaft engines as fuel extenders will also be established.

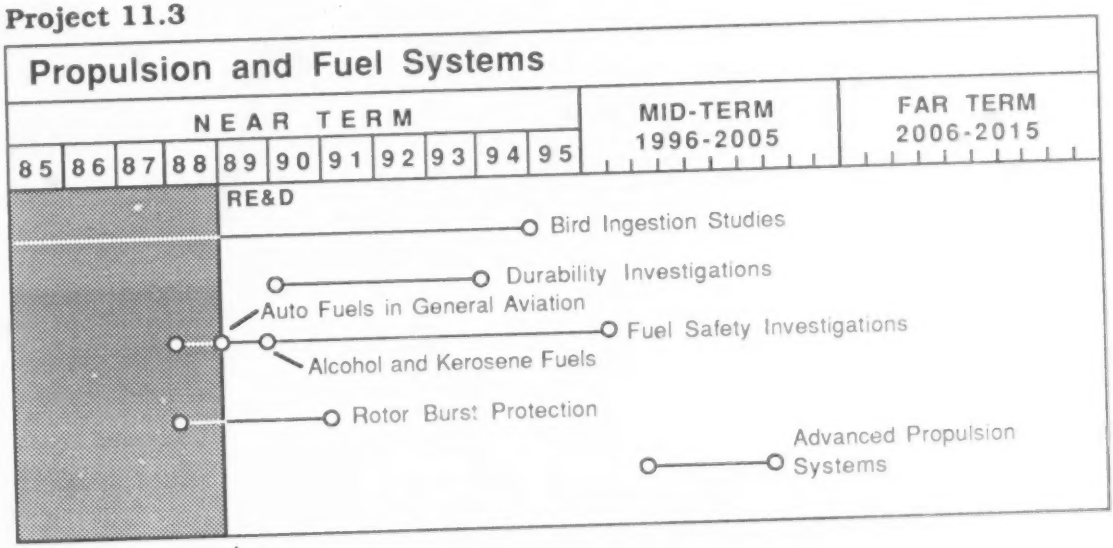
Products

- Improved bird ingestion certification criteria.
- Report on in-service experience of all classes of turbine engine bird ingestions.
- Analytical procedure to define turbine engine performance and stability during excessive rain ingestion.
- Annual analysis of uncontained turbine rotor failures.
- Reports defining the properties and characteristics of materials designed to withstand turbine rotor bursts.
- Report on fuels, materials, and techniques to mitigate powerplant involvement in post-crash fires.
- Report on alternate fuels for general aviation powerplants.

Recent Accomplishments

- Completed 2-year census of bird ingestions for B737 aircraft.
- Completed 2-year census of bird ingestions for business jet-class engines.
- Completed investigation of autogas effects on general aviation powerplants.
- Provided general technical data for revised hot-fuel climb criteria when using autogas in general aviation powerplants.
- Established annual reporting on industrywide turbine engine rotor failures.

Project 11.3



11.4 Flight Safety/Atmospheric Hazards

Responsible Division

ACD-200, Nelson Miller

Purpose

Obtain and provide the technical data necessary to develop certification standards and flight procedures for icing conditions for all categories of aircraft. Assess the airworthiness of aircraft in relation to such hazards as lightning strikes and EMI and provide guidance on software-based digital flight control and avionics systems concepts.

Approach

The worldwide atmospheric flight environment will be defined to include such parameters as supercooled clouds, snow, ice crystals, freezing precipitation, and mixed conditions, from ground level through all flight levels. In cooperation with the DoD and NASA, simulations of natural icing conditions, improved certification guidance for anti-icing and de-icing equipment, and calibration standards for icing instrumentation will be developed. Further, technologies associated with the detection of ice accumulation on an aircraft on the ground, including snow and ice particles that refreeze following de-icing with glycol-based fluids, will be investigated. With NASA's cooperation, analytical techniques and simulation methodologies will be developed for the design and testing of ice protection systems and equipment. Certification criteria for turbojet engines will also be developed based on the test cell simulation of icing parameters.

A technical database on EMI and HERF hazards will be generated using surveys; analyses; ground testing; flight testing; and simulations for establishing, validating, and updating airworthiness criteria. The adverse effects of lightning, EMI, and HERF on aircraft and advanced flight controls will be assessed.

Electromagnetic data on hazardous conditions are needed to assess airworthiness certification requirements for advanced aircraft incorporating software-based digital flight control and avionics systems. In cooperation with the National Interagency Coordinating Group, concerns such as lightning flight test data, hazard definition, modeling, and protection concepts will be investigated. Certification criteria and guidance material will be developed as well.

The Digital Systems Validation Handbook (Volume II) will be drafted, incorporating technical information for use in regulatory actions dealing with technological and certification issues that involve advanced aircraft and software-based digital flight control and avionics systems. A workshop will be conducted to provide FAA and industry state-of-the-art concepts in the digital systems validation process. Current civil and military efforts in the integrated systems approach of multiple aeronautical disciplines (under consideration for application in future aircraft) will be investigated. Initial investigative efforts will focus on fly-by-wire and fly-by-light software-based digital flight control systems, electromechanical actuators, artificial intelligence expert systems, voice command and control, and pilot/vehicle system concepts.

Flight control, structures, propulsion systems, and crew integration concepts will be reviewed to identify critical systems and pilot/vehicle interface problems.

Products

- Atmospheric characterization reports (contiguous United States, or CONUS).
- Aircraft icing handbook.
- Atmospheric characterization reports (worldwide).
- Engine icing and similitude testing reports.
- Reports on droplet trajectories, impingement, and ice accretion.
- Electro-impulse de-icing system test reports.
- Calibration standards for icing instrumentation.
- Report on airborne lightning threat.
- Handbook on aircraft lightning protection.
- Handbook on high-energy radio frequency fields.
- Study on effects of aircraft-generated EMI.
- Digital Systems Validation Handbook (Volume II).
- Guidance criteria and advisory information on digital systems.

Recent Accomplishments

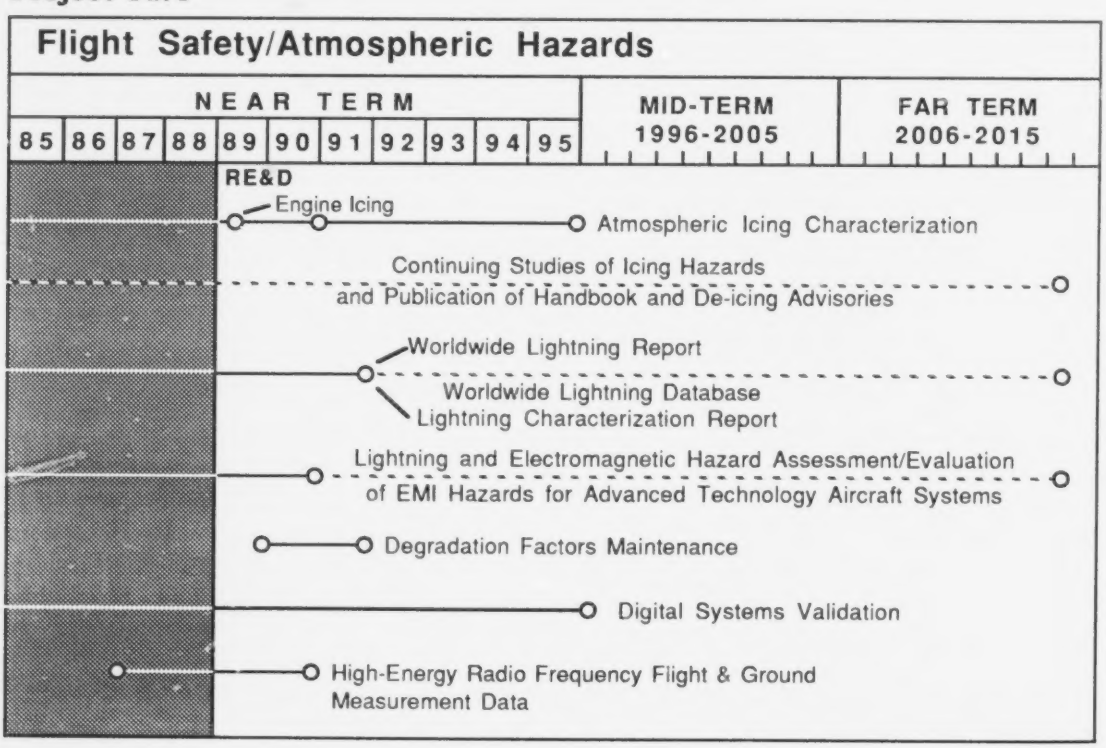
- Draft update of advisory circular on aircraft ground de-icing.
- Report - "An Empirical Look at Tolerances in Setting Icing Test Conditions with Particular Application to Icing Similitude."
- Report on CONUS snow/ice crystal atmospheric environment.
- Report - "Experimental and Theoretical Study on the Ice Accretion Process During Artificial and Natural Icing Conditions."
- Report - "3-D Trajectory Analysis of Two Droplet Sizing Instruments: OAP and FSSP."
- International Aerospace and Ground Conference on Lightning and Static Electricity conducted.
- Development of worldwide lightning database initiated.
- User manual - "Protection of Airplane Fuel Systems against Fuel Vapor Ignition due to Lightning."
- User manual - "Protection of Aircraft Electrical/Electronic Systems against the Effects of Lightning."

- Report - "Hardware Fault Insertion and Instrumentation Systems."
- Report - "Digital System Bus Integrity."
- Report - "Aircraft Electromagnetic Compatibility."
- Report - "Lighting Simulation Techniques."
- Report - "Avionics and Systems Design for High-Energy Fields."
- Report - "Determination of Electrical Properties of Grounding, Bonding, and Fastening Techniques for Composite Materials."

Related Projects/Activities

- National Icing Program (Office of the Federal Coordinator for Meteorology) -- Developed jointly by the FAA, DoD, NASA, the National Science Foundation, the National Oceanic and Atmospheric Administration, and the Office of the Federal Coordinator for Meteorology, this plan identifies national needs in the area of icing research.
- National Interagency Coordinating Group on Atmospheric Electricity and the All-directorate Lightning Criteria Team (National Interagency Coordinating Group) -- Provides the necessary coordination and interface between other government organizations and the FAA to ensure that maximum benefits are achieved through a commonality of efforts.

Project 11.4



11.5 Rotorcraft Simulator Standards

Responsible Division

ADS-200, William F. White

Purpose

Establish necessary criteria and guidance for rotorcraft simulators used for the training or evaluation of crew members.

Approach

The major problems observed in rotorcraft simulator characteristics are in the hover and low-speed flight phases. These are manifested by pilot-induced oscillations in height control, which in turn cause lateral and longitudinal control problems. Such problems may result from insufficient visual and motion information from which to detect small changes in translational displacement, velocity, and height. While the causes of these difficulties have not been positively identified, it is suspected that visual scene resolution and motion system performance are major factors.

This project comprises several different areas of activity. Minimum field-of-view requirements, both vertical and horizontal, will be evaluated to replicate the handling characteristics of actual rotorcraft.

Minimum visual scene details will also be established, including scene resolution, color, brightness, texture, and depth of field. Visual system transport delay or the minimum time lag allowable without an effect on the pilot's ability to control the vehicle will be addressed.

Additional project activities will focus on motion system requirements. The minimum degree of freedom required for appropriate pilot cuing will be evaluated, including consideration of both alerting-acceleration and feedback-to-pilot cues.

Minimum performance level for each degree of freedom (such as travel limits, frequency response, and time delay) will be assessed. Important considerations in this task include the motion cues required to alert the pilot that action is required on his part and of the appropriate motion environment for effectively controlling the vehicle.

Optimum drive algorithms for rotorcraft will be defined. This will include evaluation of current motion algorithms in light of the performance-level concerns discussed above. The drive techniques used should be considered in terms of the flight phase; that is, the techniques for the flying in-ground effect phase of flight may be different than those for the flying out-of-ground effect phase. It is highly possible that the current techniques being used are minor modifications of those developed for airplanes and may therefore not be appropriate for rotorcraft. This would necessitate the development of a completely new approach.

The synchronization between motion cuing and visual cuing, which is critical to the foregoing evaluations and analyses, will also be addressed. While each has its own problem areas to be researched, coordination of the two cannot be ignored. An analysis defining the relationships

best copy available

between motion and visual cuing is a necessary requirement for the final development of qualification criteria for rotorcraft simulators.

This project will evaluate current rotorcraft mathematical models used in simulators, especially for the flying in-ground effect, and identify any deficiencies. The adequacy of available aeronautical data for helicopter simulators, especially for in-ground effect flight and hover, will also be established. Where there are inadequacies, a test program will be developed to determine the best method for collecting the required data.

Products

- Report on the horizontal and vertical field-of-view analysis.
- Analysis of the amount, degree, and quality of a visual scene report.
- Analysis of the latency period between a pilot input and response of the visual system report.
- Draft advisory circular defining degrees of freedom needed to provide disturbance and maneuver cues.
- Draft advisory circular defining performance levels of each degree of freedom.
- Evolution of available aeronautical data.
- Report on optimum drive algorithms.
- Report on relationships between motion and visual cuing.
- Report on in-ground effect and hover mathematical models.
- Report on deficiencies in available aeronautical data.

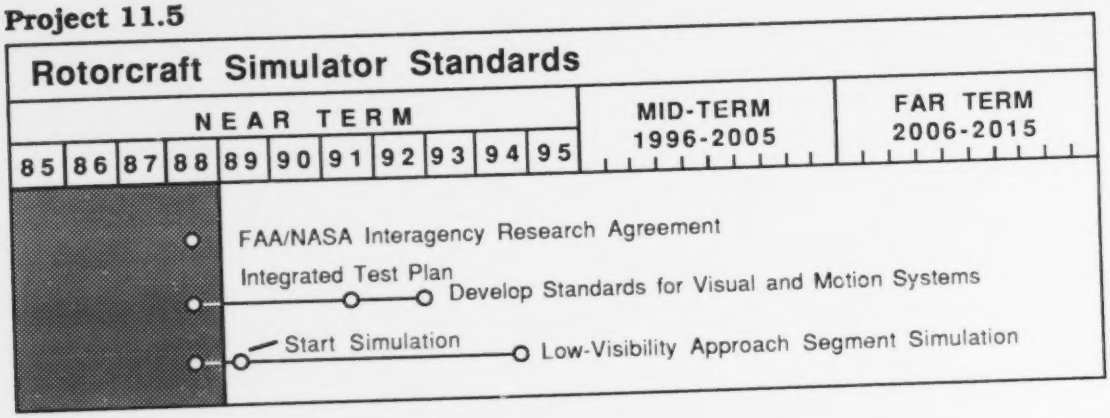
Recent Accomplishments

None.

Related Projects/Activities

- Rotorcraft wake-vortex avoidance -- Provides definitions and specifications for rotorcraft wake vortex and downwash flow fields.

Project 11.5


Rotorcraft Simulator Standards
NEAR TERM
85 86 87 88 89 90 91 92 93 94 95
MID-TERM 1996-2005
FAR TERM 2006-2015
FAA/NASA Interagency Research Agreement
Integrated Test Plan
Develop Standards for Visual and Motion Systems
Start Simulation
Low-Visibility Approach Segment Simulation

11.6 Rotorcraft/Power Lift Vehicles Display and Control Studies

Responsible Division

ADS-200, William F. White

Purpose

Develop crew performance behavioral criteria that can be used to evaluate and certify new cockpit display and control technology for rotorcraft and civil tiltrotor use.

Approach

Evaluate current state-of-the-art in-flight performance assessment and cockpit technology. Assess current and anticipated operational requirements for rotorcraft/power lift vehicles. Identify information requirements and conduct task analyses of critical instrument meteorological conditions flight operations. Develop crew and aircraft performance standards for determination of display and control integration requirements for representative performance-critical rotorcraft operations.

Products

- Report on characterization of performance-critical rotorcraft operations for determination of display and control interaction requirements.
- Report on rotorcraft/power lift vehicles information-transfer requirements for development of static display criteria.
- Report on crew performance issues requiring special attention.
- Report on human performance criteria for use in cockpit certification.

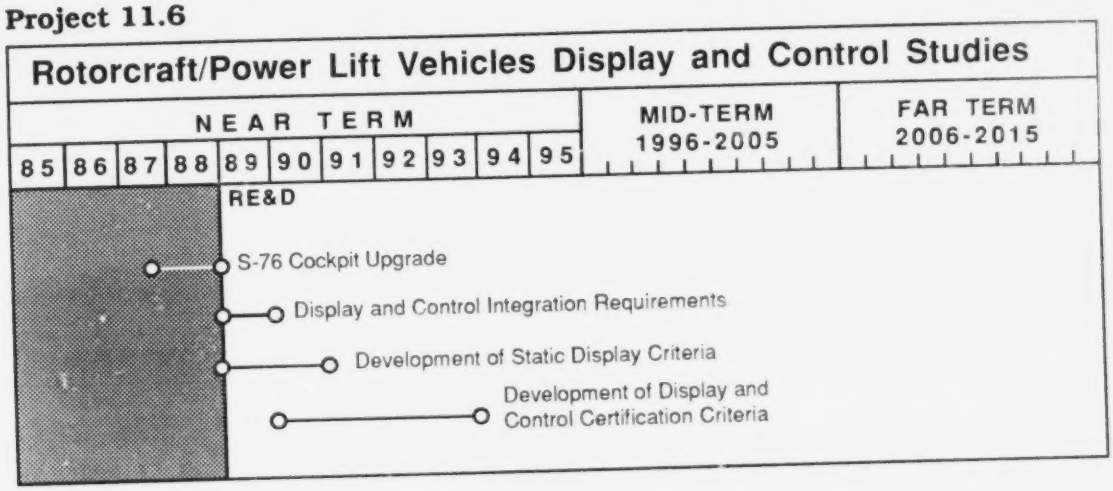
Recent Accomplishments

- Completion of S-76 cockpit upgrade.

Related Projects/Activities

- Rotorcraft Simulator Standards -- Provide means of evaluating different display designs.

Project 11.6


Rotorcraft/Power Lift Vehicles Display and Control Studies
NEAR TERM
85 86 87 88 89 90 91 92 93 94 95
MID-TERM
1996-2005
FAR TERM
2006-2015
RE&D
S-76 Cockpit Upgrade
Display and Control Integration Requirements
Development of Static Display Criteria
Development of Display and
Control Certification Criteria

11.7 Tiltrotor Certification Support

Responsible Division

ADS-200, William F. White

Purpose

Support the regional certification efforts for the civil version of the V-22 Osprey tiltrotor and the new civil tiltrotor expected to be in commercial service in 1995.

Approach

Develop tiltrotor certification criteria for technical issues relating to human performance, to the transition and approach phases of flight, and to aviation system integration. Utilize DoD V-22 data and experience to accelerate establishment of criteria.

Products

- Research reports documenting the results of various test efforts.
- Technical basis for engineering decisions on tiltrotor configurations.

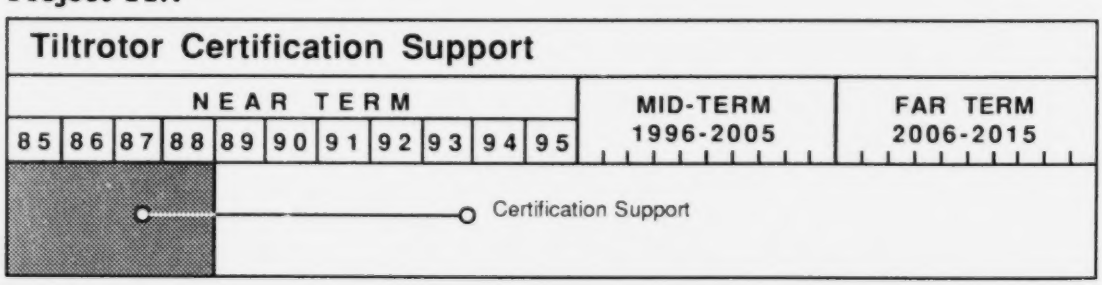
Recent Accomplishments

- Tiltrotor R&D workshop.

Related Projects/Activities

- Rotorcraft/Power Lift Vehicles IFR Operations Evaluation.
- All other tiltrotor-related projects.

Project 11.7



11.8 Aging Aircraft

Responsible Division

ACD-200, Nelson Miller

Purpose

Develop an appropriate database for evaluating the safety of and reducing the risks associated with operation of older in-service aircraft and engines. Generate airworthiness criteria, technical materials, and techniques for maintenance and inspection. This issue is accentuated by the increasing number of aging aircraft in service.

Approach

Generate the technical data needed to support the development of certification standards, performance criteria, advisory materials, and airworthiness directives that promote the safety of aging in-service metal aircraft and engines.

Investigate methods to access the integrity of and detect structural problems associated with aging aircraft. Analyze the durability of engine components as they age and document results.

Failure mechanisms relating to age, fatigue, corrosion, crack propagation, multiple site cracking, deterioration bead failures, or delamination of airplane structures and powerplants will be studied to determine how such factors cause damage and how this damage can be predicted, prevented, or arrested.

Initial efforts will also be directed toward obtaining and analyzing all published information on current nondestructive inspection techniques and equipment to determine those that are most applicable and effective for use on metal airplanes and their powerplants.

The development and enhancement of nondestructive inspection equipment, procedures, and training will be studied. New training programs, which include handbooks, videos, and other aids, will be developed for inspection and maintenance personnel.

Products

- Analysis of effects of age and engine durability and reliability.
- Current practices analysis.
- Operational and environmental determinations.
- Maintenance and inspection criteria.
- Predictive and preventive technology development.

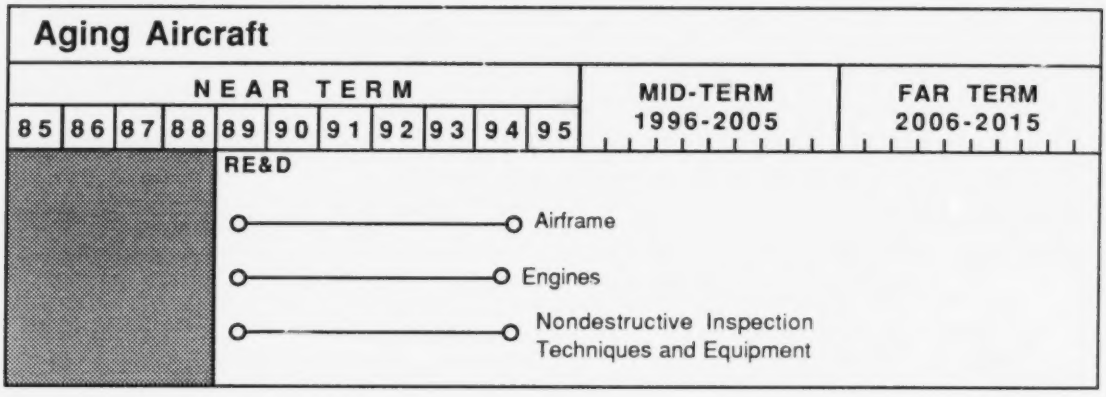
Recent Accomplishments

- Support of the Aging Aircraft Conference.

Related Projects/Activities

- Aircraft Crashworthiness/Structural Airworthiness.
- Propulsion and Fuel Systems.
- International Airworthiness Database.

Project 11.8



11.9 International Airworthiness Database

Responsible Division

ACD-200, Nelson Miller

Purpose

Develop and implement a computer-based filing system and database that will track civil aircraft registry owners and operators on an international level to ensure that unairworthy aircraft are fixed or removed from service. A series of recent actions have imposed pyramiding demands on the current U.S. Aircraft Registry tracking system.

Approach

Develop prototype methodology and equipment that will enable the FAA to fulfill airworthiness charter requirements in a more expeditious and efficient manner. Initial efforts will identify the FAA's true requirements in a Master Requirements and Implementation Plan.

Determine shortcomings in database material and equipment when compared against true requirements using prototype system. Produce a final report with recommendations for termination or system enhancements to more fully address the true requirements in the master plan.

Products

- Master Requirements and Implementation Plan.
- Prototype database and processing system.
- Final report on system operability.

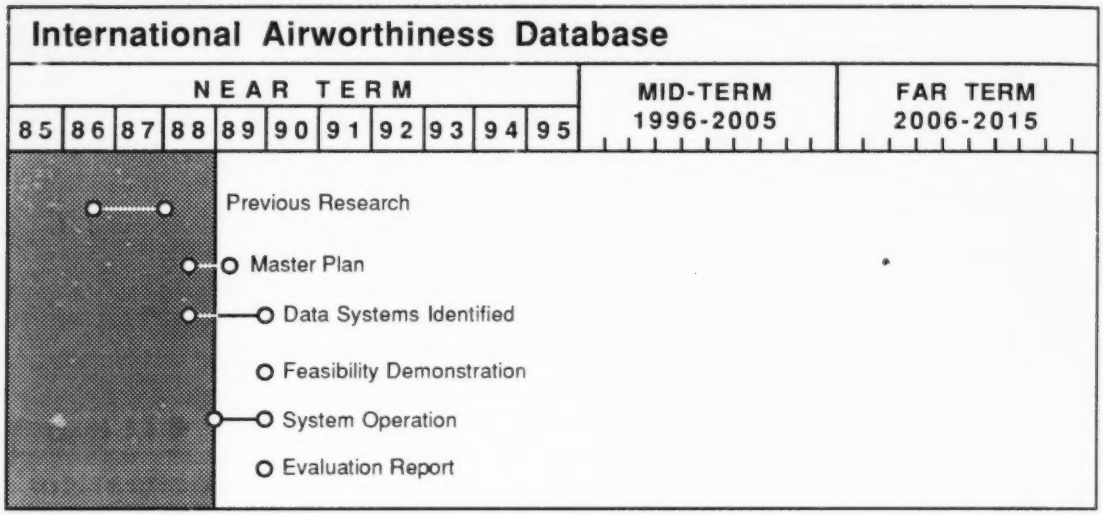
Recent Accomplishments

None - new start.

Related Projects/Activities

- Aging Aircraft.

Project 11.9


International Airworthiness Database
NEAR TERM
85 86 87 88 89 90 91 92 93 94 95
MID-TERM
1996-2005
FAR TERM
2006-2015
Previous Research
Master Plan
Data Systems Identified
Feasibility Demonstration
System Operation
Evaluation Report

12. Aviation Medicine

Aviation medicine covers a broad spectrum of work related to medical, behavioral, and human factors technology. The FAA's work in this area is aimed at promoting not only the safety of civil aviation, but also the health, safety, and efficiency of agency employees. The four projects in this technical area are:

Aviation Medicine	
12.1	Work Force Optimization Research
12.2	Human Performance Research
12.3	Protection and Survival
12.4	Aeromedical Program Support

Various organizations within the agency, including Air Traffic, Human Resources, Flight Operations, Airworthiness, and the Technical Center, request specific aeromedical research projects addressing their human-oriented problems. Most of these research efforts are conducted in-house at the Office of Aviation Medicine's (OAM) Civil Aeromedical Institute (CAMI) in Oklahoma City. Their efforts are supplemented by OAM headquarters, contractors, and the FAA Technical Center.

OAM research facilities include a hypobaric test chamber, protective breathing equipment, and a water-survival test laboratory; a dynamic impact test track; and computerized radar simulation equipment for the assessment of air traffic control (ATC) procedures. Also available are modern laboratories for toxicological research, accident investigation, and studies of human behavior and performance, with particular emphasis on ATC problems. These laboratories are used to examine a variety of problems, including the development of impact test criteria for air carrier passenger seats, studies of stress fatigue for air traffic controllers, the relationships of various indices of airman performance to age, and the development of new selection and training methods.

Over the next several years, one can expect that advances in the technology of airspace management will result in a smaller, more efficient, and more specialized agency work force. Changing characteristics of the airman population and the introduction of new carriers, equipment, and procedures will all require continuing OAM research efforts to ensure the highest level of civil aviation safety. Of particular concern will be the changing roles of pilots and controllers as increasing levels of automation are introduced.

The major objectives of the aviation medicine research projects are as follows:

- Develop comprehensive statistical and conceptual database systems for optimizing the productivity and performance of the agency's operational work force and improving management selection, training, evaluation, and practices at a minimum cost to the public.
- Develop procedures and analytical techniques for reducing human errors in the operation of the national aviation system.

- Develop appropriate medical standards for airmen and agency operational personnel and maintain a high level of occupational health and safety standards in a cost-effective manner.
- Reduce the potential for injury or loss of life following aircraft accidents or incidents.

OAM research projects differ in certain respects from projects oriented toward the development of some specific piece of hardware. These programs emphasize the human aspects of other major projects, such as the Advanced Automation System (AAS), Voice Switching and Control System Development, and Automated En Route Air Traffic Control 3. As advances in human factors technology are made, such projects will be modified and enhanced in an effort to optimize the efficiency and safety of the total aviation system.

12.1 Work Force Optimization Research

Responsible Division

AAM-500, William Shepard

Purpose

Increase the efficiency and productivity of agency personnel through the application of human factors research, while at the same time maintaining and enhancing positive employee attitudes.

Approach

Develop a personnel tracking system to monitor variations in personnel performance resulting from the introduction of new equipment, fatigue, illness, use of drugs, and other job stresses. Include such factors as operational errors, controller performance ratings, training results, and duty assignments. Identify changes as they occur, and describe when and where they occur. Relate these changes to resulting new personnel requirements and to old tasks that are eliminated. Create new tests and procedures for selecting personnel and measuring performance. Identify requirements for new training equipment and courses. In this connection, new training syllabi will be cooperatively developed with agency human resources specialists for use in academy training of air traffic controller candidates. As students are trained, the database will be continually expanded and used for the evaluation of selection procedures and training courses.

Develop tracking systems to relate controllers' on-the-job performance to selection criteria, testing, and specific training factors. Evaluate specific training programs, such as the Airway Science program. Statistically analyze data to define the profile of an individual likely to succeed in the training schools and to evaluate the performance of students and instructors. Design customized databases to meet other specialized requirements that may arise.

Develop databases to support FAA efforts to improve management selection, training, evaluation, and practices. (Employee attitude surveys and other evaluations since the 1981 PATCO strike have indicated problems in the management and supervision of human resources.) Continue research and human resource program support, including consultation and database development, in the areas of supervisory and managerial selection, development, and evaluation, as well as subordinates' appraisals of managers. Provide support for management decision making, the Management Training School curriculum, the Airway Science Curriculum Demonstration Project, and computer-based instruction for technical and organizational development systems.

Develop airport concourse boarding gate screening profiles for use by agency and airport security personnel. These profiles require constant updating and revision to reflect current characteristics of potential security-risk populations.

Products

- Encyclopedic, state-of-the-art report on the selection of air traffic controllers.
- Criteria for identifying training and equipment needs.
- Methods for evaluating training programs.
- Guidelines for security personnel to follow for detection of potential hijackers and terrorists.
- New performance tests, rating methods, and procedures for evaluating air traffic controllers.
- Statistical models and methods for prediction of on-the-job performance for comparison with observed performance, particularly with new equipment and procedures.
- Statistical models for subordinate and peer appraisals of supervisors and Administrator's Management Team members.
- Training syllabi for air traffic controllers.

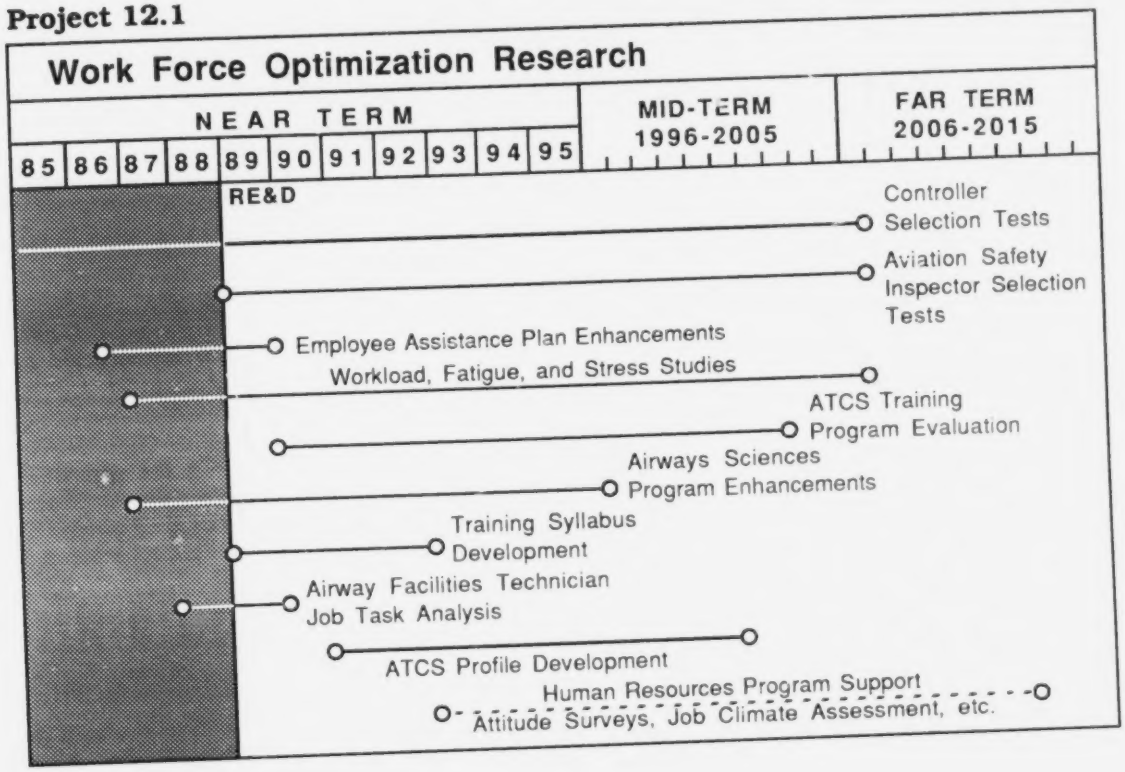
Recent Accomplishments

- Second Agency Workforce Attitude Survey completed.
- Supervisor - Phase I course evaluation completed.
- Study of fatigue effects of air traffic control specialist (ATCS) conflict detection completed.
- New forms of controller aptitude and occupational knowledge tests developed.
- Study on the hiring, testing, and training knowledge of boarding gate screening personnel completed.
- Study of Airway Science Demonstration Project completed.

Related Projects/Activities

- Aeromedical Program Support -- Will provide revised color-vision tests and standards that will become part of the ATCS selection process and related work force studies.
- Advanced Automation System (AAS) -- Will produce new equipment and procedures that must be considered in developing critical air traffic control personnel characteristics.

Project 12.1


Work Force Optimization Research
NEAR TERM
MID-TERM 1996-2005
FAR TERM 2006-2015
85 86 87 88 89 90 91 92 93 94 95
RE&D
Controller Selection Tests
Aviation Safety Inspector Selection Tests
Employee Assistance Plan Enhancements
Workload, Fatigue, and Stress Studies
ATCS Training Program Evaluation
Airways Sciences Program Enhancements
Training Syllabus Development
Airway Facilities Technician Job Task Analysis
ATCS Profile Development
Human Resources Program Support
Attitude Surveys, Job Climate Assessment, etc.

12.2 Human Performance Research

Responsible Division

AAM-500, William Shepard

Purpose

Enhance understanding of the human function in the complex environment of ATC and cockpit systems in support of agency rulemaking activity.

Approach

Assessment of the workload and performance of ATC personnel has been a matter of active scientific study for decades. It is now possible to measure productivity objectively through task analyses and simulation. However, other aspects of air traffic control specialist performance remain to be studied. This project will closely monitor the progress of similar ongoing programs within the National Aeronautics and Space Administration, the Department of Defense, and industry. Extensive test facilities will be used for conducting a broad range of investigations. These facilities include, among others, a vision tester for measuring 10 vision parameters; a multiple task performance apparatus for evaluating responses to stress conditions; a disorientation device for assessing the effects of the interaction of motion and other stress factors on performance; and simulated controller suites for research on the effects of such factors as age, stress, and rest. The following areas will be investigated:

- Advanced automation -- The general characteristics of an advanced automation ATC system will be examined and a realistic estimate made of the associated workload. Based on a systematic data analysis, this project will attempt to identify work conditions that lead to boredom, inattention, stress, and fatigue. Methods for reducing or eliminating these effects will be tested.
- Controller performance measurement -- A major initiative is the development and validation of objective means for measuring specific aspects of controller performance. This effort will provide a baseline for future workload and error assessments and a possible field evaluation tool. Feasibility studies at the radar training facilities of the FAA Academy will result in a standardized computer-based system for performance measurement. Supporting needs, such as job-related visual acuity and color vision tests, will be developed and validated.
- Airman performance measurement -- The vast majority of aircraft accidents result from a variety of pilot errors. These errors are associated with deficiencies in training, proficiency, equipment and systems design, management, and judgment. Because errors in judgment are responsible for many general aviation accidents, efforts are planned to evaluate cockpit resource management and judgment training for these airmen. Long-term studies will be made of the error rates of airman groups who have or have not received judgment training in their primary

syllabus or judgment counseling following an accident and incident. Special attention will be given to air carrier crews.

- Operational error evaluation system -- A goal of the National Airspace System Facilities and Equipment Plan is to reduce ATC operational errors by 80 percent by 1995. To accomplish this, the FAA will need enhanced techniques for accurate classification of operational errors and a fundamental understanding of their causes. This project will develop an operational errors database designed to identify underlying situation- and human-related causes and to serve as a basis for selection and training systems and the identification of possible preventive methods.

Products

- Reports describing methods for measuring controller workload and performance.
- Reports describing the relationship of aging, work and rest scheduling, and other work force variables to controller performance.
- Reports on the relationship of operational errors to controller selection, training, and situational variables.
- Reports on the impact of human factors on the maintenance, inspection, and testing of air carrier aircraft.
- Reports on the occurrence of operational errors by location, shift, and other situational variables.
- Reports on methods for training and evaluating pilot judgment.
- Reports on root causes of human error.
- Job-related vision tests.
- Reports on evaluation of training methods for air carrier crews.

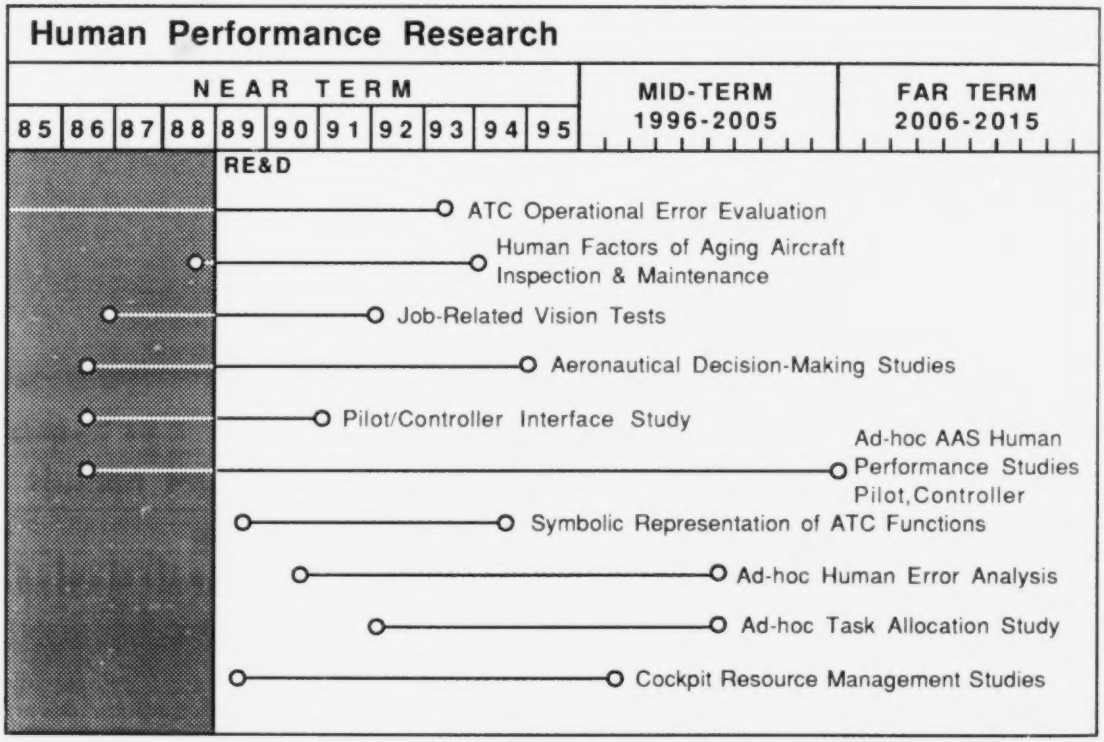
Recent Accomplishments

- Human factors study of operational errors completed.
- Data analysis completed for terminal and en route job task analysis project.
- Controller performance model developed for assessing the effects of aviation system changes on workload and performance.
- Judgment training materials for helicopter emergency medical services pilots.
- Workshop held on the human factors of aircraft maintenance and inspection.

Related Projects/Activities

- Aeromedical Program Support -- Will provide medical standards for airmen and air traffic controllers regarding conditions that may limit or enhance task performance potential.
- Flight deck systems -- Will provide data on the impact of cockpit display and control designs on crew workload and suggest changes that could reduce the risk of human error.
- Behavioral criteria for cockpit certification -- Will develop methods and quantitative behavioral criteria for cockpit certification and procedures.
- Flight crew training enhancements -- Will develop methods for improving crew training effectiveness and decreasing training cost.

Project 12.2


Human Performance Research
NEAR TERM
MID-TERM 1996-2005
FAR TERM 2006-2015
85 86 87 88 89 90 91 92 93 94 95
RE&D
ATC Operational Error Evaluation
Human Factors of Aging Aircraft Inspection & Maintenance
Job-Related Vision Tests
Aeronautical Decision-Making Studies
Pilot/Controller Interface Study
Ad-hoc AAS Human Performance Studies Pilot,Controller
Symbolic Representation of ATC Functions
Ad-hoc Human Error Analysis
Ad-hoc Task Allocation Study
Cockpit Resource Management Studies

12.3 Protection and Survival

Responsible Division

AAM-500, William Shepard

Purpose

Promote optimal survival concepts by assessing the efficacy of these concepts for protection and survival following aircraft accidents.

Approach

Protection and survival are dependent upon the interaction of people with equipment certified or approved by the FAA. The FAA's efforts directly or indirectly relate to emergency equipment and procedures. Generally, the approach is twofold: first, to support rulemaking or certification actions by evaluating the merits, deficiencies, costs, and benefits of specific safety-related appliances; and second, to promote the proper use of these appliances through educational initiatives, in cooperation with industry and airspace users. The following areas are being investigated:

- Seats and seat restraints -- Near-term regulatory initiatives have emphasized potential improvements in seats and restraint systems. Testing will support seat and restraint crashworthiness determinations and validate the seat occupant model. Tests of energy attenuation concepts and the characteristics of composite-material seats will be performed during controlled full-scale impact tests. Protection requirements for side-facing seat occupants will be determined. Far-term efforts will include tests designed to provide data on new technologies. Regulatory requirements and test procedures will reflect evolving concepts of civil airman and passenger tolerance. Close cooperation with other agencies involved in parallel human tolerance efforts will be ensured.

- Water survival -- Near-term efforts will continue to focus on the development of viable and cost-effective water survival concepts and procedures. Standards for flotation platforms will be developed; seat cushion buoyancy requirements and performance criteria will be assessed in a dynamic environment. Mid-term efforts will focus on airport water rescue requirements, such as aircraft and rescue equipment compatibility.

- Protective breathing equipment -- Near-term efforts will focus on improved technical standards for protective breathing equipment used by aircraft crews. The effectiveness of new criteria will be evaluated against the range-of-profile characteristics of the crew population. Tests of passenger protection will be completed. Future studies will be directed toward passenger and crew protection standards for advanced technology aircraft.

- Toxicity -- To develop reasonable standards for cabin interior materials, it is necessary to derive limits for smoke and toxic gas production. This program will

continue to support the development of a small-scale toxicity test procedure that will correlate with full-scale tests conducted under the Aircraft Fire Safety project. Additionally, some effort will continue on the fundamental understanding of the combined effects of irritants and toxic gases; this effort will contribute to the development of a hierarchy of materials with respect to their human toxicity.

- Evacuation -- Special studies will be conducted to support other agency development programs.
- Shoulder harnesses -- Motivational factors in the use of shoulder harnesses by general aviation pilots will be studied.
- Exit rates -- Laboratory evaluations of passenger flow rates through exits will be performed.
- Air quality -- Airline cabin air quality as a safety factor will be studied.

Products

- Human tolerance data and criteria to support the certification of aircraft seats and restraint systems.
- Criteria to support the certification of flotation and onboard rescue equipment.
- Criteria to support the certification of protective breathing equipment and operational procedures.
- Criteria to support the certification of fire, smoke, and toxicity limits of aircraft interiors.
- Criteria to support the certification of cabin safety and evacuation. (A notice of proposed rulemaking on emergency lighting has recently been issued that indicates the types of criteria being planned.)

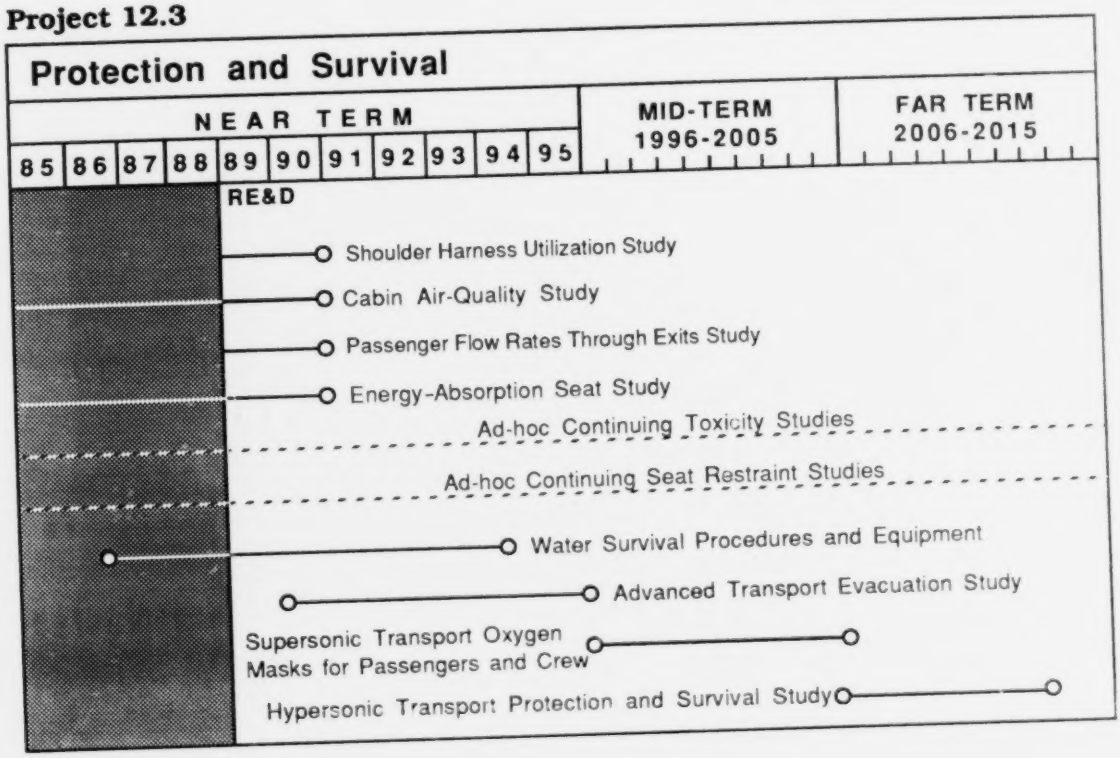
Recent Accomplishments

- Static and dynamic tests of six seat and restraint combinations.
- Study of effects of seating configurations on exit access.
- Study of protective breathing requirements under workload.
- Study of cabin evacuation while using protective breathing devices.

Related Projects/Activities

- Aeromedical Program Support -- Biomedical, pathological, and toxicological investigations of accidents will define injury mechanisms toward the revision of protection and survival equipment and procedures.

Project 12.3


Protection and Survival
NEAR TERM
MID-TERM 1996-2005
FAR TERM 2006-2015
85 86 87 88 89 90 91 92 93 94 95
RE&D
Shoulder Harness Utilization Study
Cabin Air-Quality Study
Passenger Flow Rates Through Exits Study
Energy-Absorption Seat Study
Ad-hoc Continuing Toxicity Studies
Ad-hoc Continuing Seat Restraint Studies
Water Survival Procedures and Equipment
Advanced Transport Evacuation Study
Supersonic Transport Oxygen Masks for Passengers and Crew
Hypersonic Transport Protection and Survival Study

12.4 Aeromedical Program Support

Responsible Division

AAM-500, William Shepard

Purpose

Improve aviation safety by ensuring the health of flyers through the medical certification program and educational efforts. Improve agency work force efficiency by providing healthful work environments for agency employees.

Approach

A series of studies will be undertaken to support the following data needs of the Federal Air Surgeon:

- Aeromedical certification and standards -- A complete review of the aeromedical standards of Federal Aviation Regulations Part 67 will be undertaken by aeromedical experts. This 2-year initiative is expected to result in a series of recommendations for rulemaking following the reviews required by the Administrative Procedures Act. A final report by the experts will be prepared at the conclusion of the effort. Current activities include a study designed to evaluate the effects of therapeutic drugs on human performance and studies using epidemiological methodology for correlating medical certification decisions with safety-related databases to demonstrate the validity of administrative actions.
- Medical accident investigation -- Recurring and special studies are undertaken in response to the National Transportation Safety Board, industry, and the Federal Air Surgeon to determine potential crew incapacitation and medical factors associated with aircraft accidents. From these studies, common factors and injuries are identified and reported to support national educational and regulatory actions. Far-term trends, such as incidence of elevated blood alcohol and drugs, can be assessed this way.
- Occupational health -- Agency occupational health programs and their costs constitute a major responsibility of the Federal Air Surgeon and require data analyses. These analyses identify the measurable benefits of special intervention programs designed to lower the cost of public services. Of particular importance are those health impacts potentially unique to FAA occupations. Special research studies will be undertaken in response to potential or alleged occupational hazards as they are identified.
- Aeromedical education -- These activities provide the mechanism for the training of FAA-designated aviation medical examiners. They also serve a valuable safety purpose through promotion of nonregulatory concepts that are significant to the pilot's health. Generally, pilots' aeromedical educational activities are directed toward classic concepts in flight physiology, aviation psychology, and aeromedical

problems. Additionally, special-emphasis topics such as accident investigation, survival training, and aviation examiner seminars are promoted.

Products

- Annual reports on alcohol- and drug-related accidents.
- Revised standards for evaluating medical criteria and procedures.
- Criteria to support the regulatory process in the areas of crashworthiness and drug use.
- Toxicology of fatal accidents (continuous).
- Toxicity studies of burning materials and noxious gas mixtures.
- Guidelines for processing mass-casualty accidents.
- Handbook on radiation effects.
- Aeromedical-related pamphlets for use in the accident prevention program.

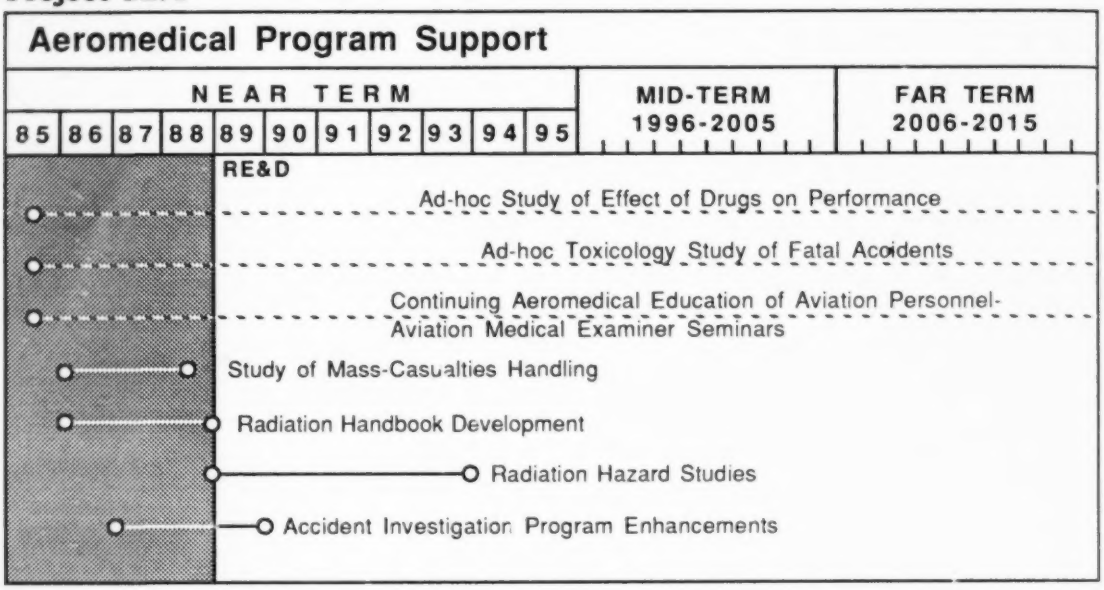
Recent Accompiishments

- Vision research unit activated.
- Draft advisory circular on cosmic radiation exposures for aircrew completed.

Related Projects/Activities

- Aircraft Systems Fire Safety -- Will identify new cabin-interior materials for the investigation of toxicological effects.

Project 12.4


Aeromedical Program Support
NEAR TERM
85 86 87 88 89 90 91 92 93 94 95
MID-TERM
1996-2005
FAR TERM
2006-2015
RE&D
Ad-hoc Study of Effect of Drugs on Performance
Ad-hoc Toxicology Study of Fatal Accidents
Continuing Aeromedical Education of Aviation Personnel-
Aviation Medical Examiner Seminars
Study of Mass-Casualties Handling
Radiation Handbook Development
Radiation Hazard Studies
Accident Investigation Program Enhancements

13. Security

The objective of the aviation security program, which supports the security mission described in Sections 4.2.3 and 4.3.9 of Volume I, is to develop countermeasures against terrorist and criminal threats. The FAA Office of Civil Aviation Security manages RE&D projects aimed at developing new and improved methods for detecting weapons and explosive devices and enhanced system operations. There are four projects in this technical area:

	Detection Systems
13.1	Explosives Detection
13.2	Weapons Detection

	System Operations
13.3	Airport Security
13.4	Security Systems Integration

Hijacking and terrorist threats are becoming increasingly sophisticated. This security problem has been compounded by a diversity of available commercial explosives and the illegal use of military explosives. Similarly, the growing use of new alloys and nonmetallic materials in weapons has made detection more complex.

Studies are under way to develop a flexible security program designed to counter current and projected hijacking and terrorist threats. Improved explosives and weapons detection techniques are currently under development. The agency is also studying the effectiveness of systems and procedures needed to counter different levels of future threats without placing undue burden on the industry or the traveling public.

13.1 Explosives Detection

Responsible Division

ACD-100, William Wall

Purpose

Develop improved systems for detecting explosives in checked and carry-on baggage, in air cargo, and on passengers.

Approach

The FAA is working on the development of two basic types of explosives detectors: one designed to collect, analyze, and identify vapors from different explosives and the other designed to use electromagnetic energy or nuclear radiation to penetrate and identify bulk explosives based on their elemental or structural composition.

Several prototype detection systems are under development. In addition, a number of new technologies are being identified and evaluated, with those shown to be highly promising advancing to a prototype development phase.

Products

- Prototype hardware and testing.
- Project evaluation reports.
- Engineering procurement specifications.
- Operational procedures.

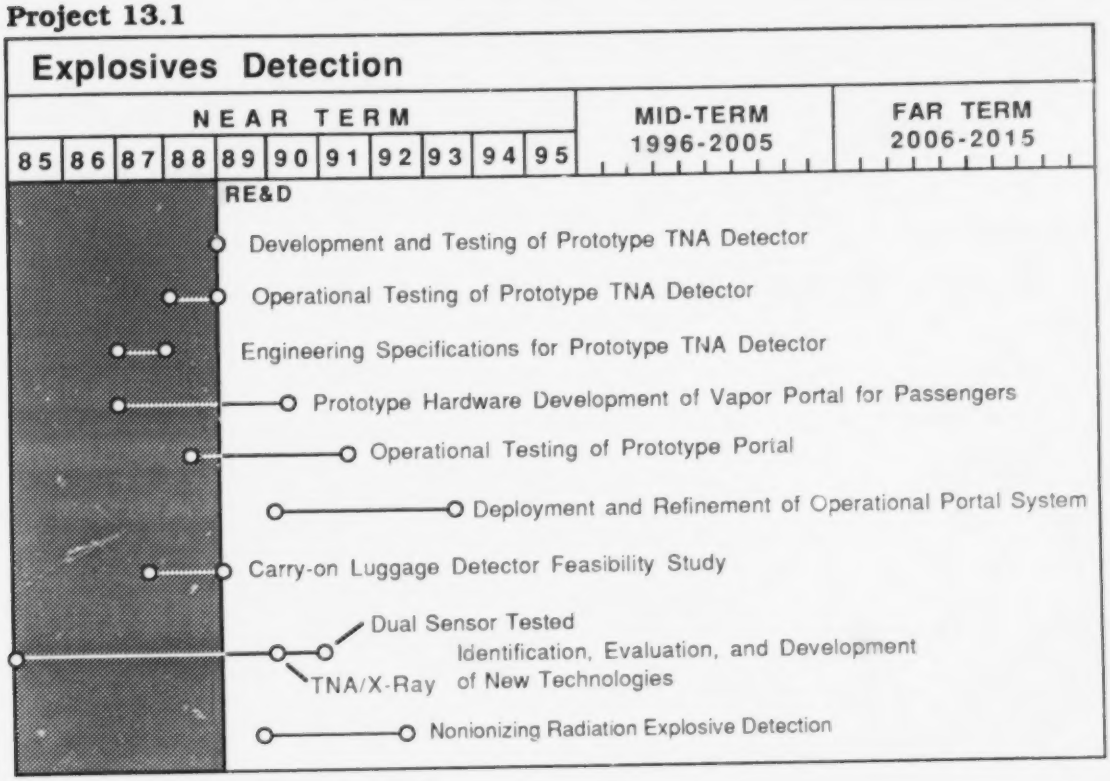
Recent Accomplishments

- Airport tests of two prototype thermal neutron activation (TNA) detection devices successfully completed.
- Airport tests of prototype vapor detection portal for passengers in process.
- Thermal neutron analysis systems procured with facilities and equipment funds.
- Solicitations of industry and academia to identify and develop technologies to increase explosives detection efficiency and effectiveness.

Related Projects/Activities

None.

Project 13.1


Explosives Detection
NEAR TERM
85 86 87 88 89 90 91 92 93 94 95
MID-TERM
1996-2005
FAR TERM
2006-2015
RE&D
Development and Testing of Prototype TNA Detector
Operational Testing of Prototype TNA Detector
Engineering Specifications for Prototype TNA Detector
Prototype Hardware Development of Vapor Portal for Passengers
Operational Testing of Prototype Portal
Deployment and Refinement of Operational Portal System
Carry-on Luggage Detector Feasibility Study
Dual Sensor Tested
TNA/X-Ray
Identification, Evaluation, and Development of New Technologies
Nonionizing Radiation Explosive Detection

13.2 Weapons Detection

Responsible Division

ACD-100, William Wall

Purpose

Enhance current systems for detecting weapons on people and in carry-on luggage.

Approach

With new, lighter materials such as fiber-reinforced composites and ceramics being substituted for the conventional metal alloys in guns and other weapons, current airport metal detectors could become less effective in distinguishing weapons from benign objects. Accordingly, the FAA is working on the development of active electromagnetic and acoustic detection systems. These systems will provide positive identification of weapons with greater sensitivity.

Products

- Prototype hardware and testing.
- Project evaluation reports.
- Engineering procurement specifications.
- Operational procedures.

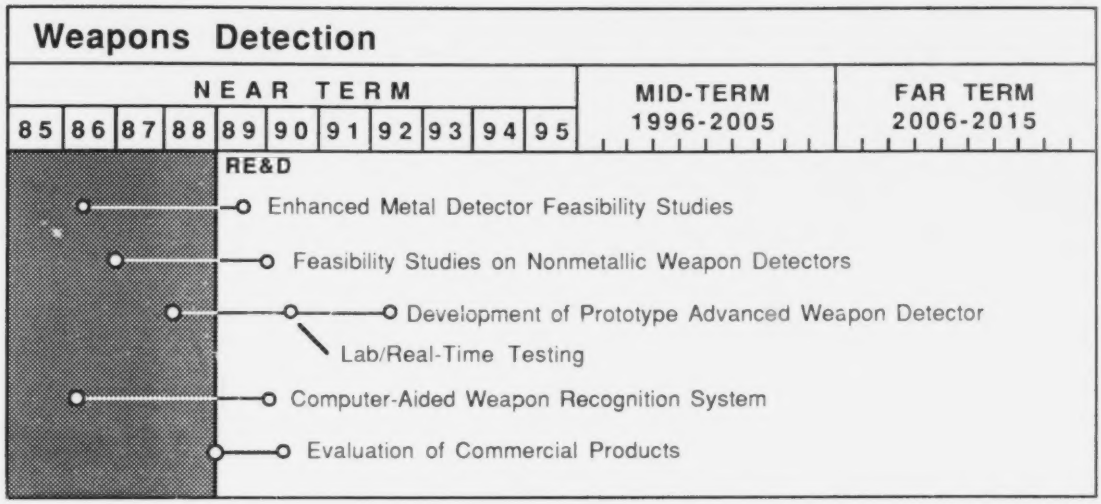
Recent Accomplishments

- Feasibility studies on nonmetallic weapons detectors.
- Study on enhancement of current weapons detectors.
- Weapon-threat surveys.
- Study on computer augmentation of x-ray screening process.

Related Projects/Activities

None.

Project 13.2


Weapons Detection
NEAR TERM
85 86 87 88 89 90 91 92 93 94 95
MID-TERM
1996-2005
FAR TERM
2006-2015
RE&D
Enhanced Metal Detector Feasibility Studies
Feasibility Studies on Nonmetallic Weapon Detectors
Development of Prototype Advanced Weapon Detector
Lab/Real-Time Testing
Computer-Aided Weapon Recognition System
Evaluation of Commercial Products

13.3 Airport Security

Responsible Division

ACD-100, William Wall

Purpose

Establish an integrated airport security plan for all threat levels.

Approach

- Define current and future threats to airport security and operations, followed by an assessment of the vulnerability of U.S. airports to these threats.
- Develop security systems and operational procedures for countering threats in an economically viable, responsive manner.
- Operationally test systems and procedures to assess effectiveness and impact on airport activities and passenger flow.

Products

- Threat definition and evaluation.
- Prototype hardware and testing.
- Project evaluation reports.
- Operational guidelines.

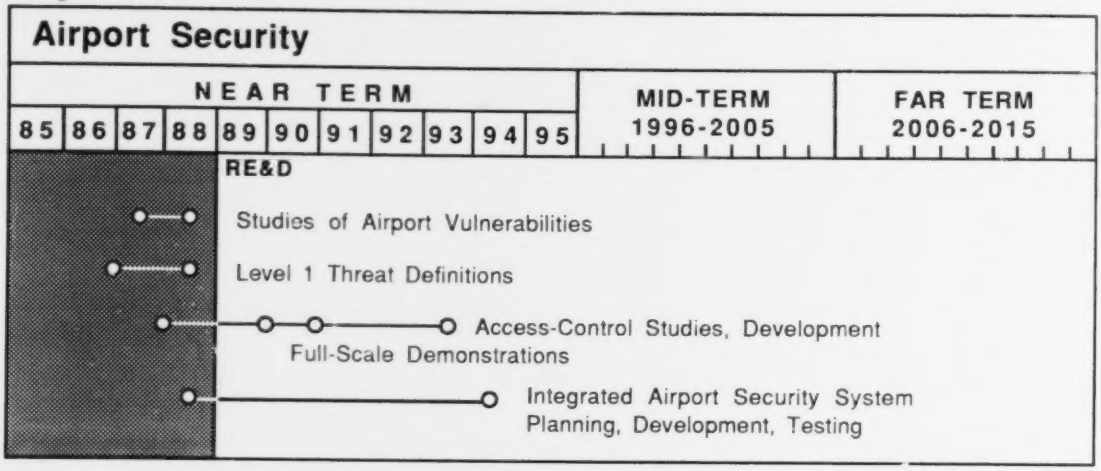
Recent Accomplishments

- Assessment of airport vulnerabilities completed.
- Definition of current threats completed.
- Classification of threat response options completed.

Related Projects/Activities

None.

Project 13.3


Airport Security
NEAR TERM
85 86 87 88 89 90 91 92 93 94 95
MID-TERM
1996-2005
FAR TERM
2006-2015
RE&D
Studies of Airport Vulnerabilities
Level 1 Threat Definitions
Access-Control Studies, Development
Full-Scale Demonstrations
Integrated Airport Security System
Planning, Development, Testing

13.4 Security Systems Integration

Responsible Division

ACD-100, William Wall

Purpose

Develop procedures and hardware for identifying and countering threats to aircraft and airport facilities.

Approach

Currently, this effort consists of a broad range of activities. One is designed to enhance the current threat profile through development of a computerized database system containing identifying traits of known hijackers and terrorists. Other activities include least-risk studies of methods for minimizing explosion damage to aircraft in flight; enhanced detection of essential bomb components; and aircraft interior design studies to minimize locations wherein weapons, explosives, and contraband may be hidden.

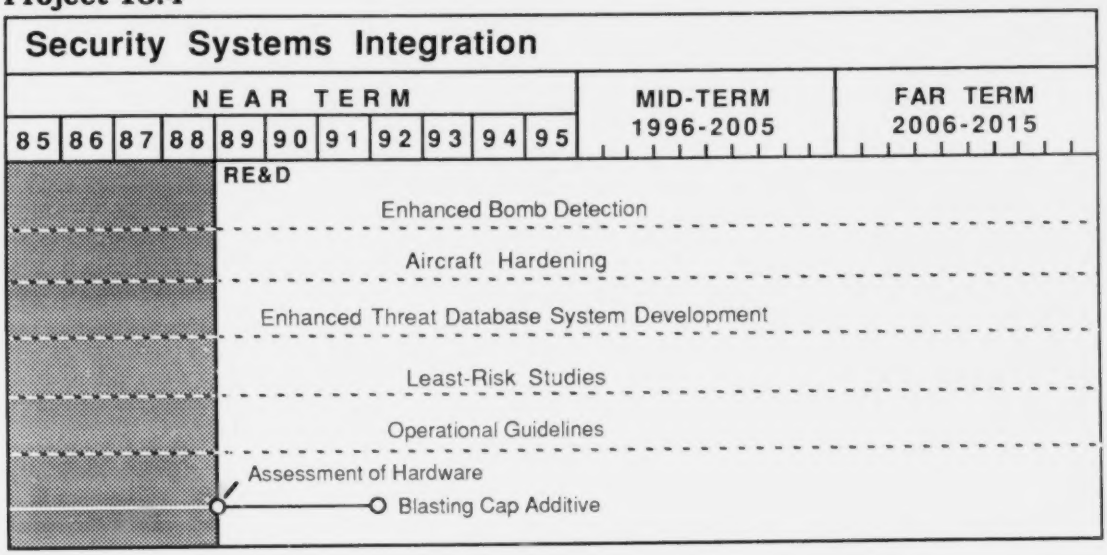
Products

- Prototype hardware and testing.
- Enhanced computerized threat database.
- Operational guidelines.
- Least-risk locations for new commercial aircraft.

Recent Accomplishments

- Passenger/baggage reconciliation studies completed.

Project 13.4


Security Systems Integration
NEAR TERM
85 86 87 88 89 90 91 92 93 94 95
MID-TERM
1996-2005
FAR TERM
2006-2015
RE&D
Enhanced Bomb Detection
Aircraft Hardening
Enhanced Threat Database System Development
Least-Risk Studies
Operational Guidelines
Assessment of Hardware
Blasting Cap Additive

14. Human Performance

The 12 projects in this technical area support the safety mission and address either air traffic controller or flight crew performance. These projects are:

	Air Traffic Controller
14.1	Controller Human Factors
14.2	AI Applications to Air Traffic Control

	Flight Crew
14.3	Causal Factors in Accidents and Incidents
14.4	Human Performance Assessment and Improvement
14.5	Information Transfer and Management
14.6	Aircraft Automation
14.7	Control and Display Technology
14.8	ATC Weather Information Transfer
14.9	Interactive Voice Systems
14.10	Flight Deck Certification Criteria
14.11	Flight Crew Certification and Training
14.12	Human Factors and Regulatory Support

Attention to the human operator's capabilities and limitations in aviation systems design and operation offers the greatest potential for increasing flight safety. Human factors research to be conducted or sponsored by the FAA in FY 1989 will concentrate on flight crew and air traffic controller performance. This program will also address the role of the human operator in automated systems and the selection, training, and certification of flight crews and air traffic control specialists. Agency research capabilities will be expanded through formal working agreements with the National Aeronautics and Space Administration (NASA), the Department of Transportation's Transportation Systems Center, and various universities.

The Air Traffic Controller

In FY 1988, a review of air traffic control (ATC) automation activities was conducted as part of an effort to examine the proper role of the human operator in automated systems. In FY 1989, the development of objective means for measuring specific aspects of controller performance will be initiated. Scenarios will be developed to facilitate the design, review, and evaluation of future ATC systems. Research will be conducted on voice recognition technology for use in control room communications. The feasibility of using artificial intelligence for training air traffic controllers will be investigated, and studies will be conducted to determine controller visual requirements.

The Flight Crew

In FY 1988, studies of safety databases were initiated to define human factors problem areas that contribute to accidents and incidents. In FY 1989, the knowledge gained will be used to investigate the proper role of the human operator in automated systems; improve the design of displays, charts, and procedures; improve training methods; and develop effective methods for the management and transfer of information. Work will be initiated to develop methods for objectively measuring flight crew performance to facilitate the evaluation and certification of advanced technology cockpit displays, cockpit procedures, and control systems, and to supplement certification criteria for new systems. Interviews, observations of crew performance, and analyses of databases will be conducted to determine the need for changes in requirements for flight training. Research will be conducted to develop crew performance criteria for use in the evaluation and certification of rotorcraft displays and controls and to establish guidelines for the design and evaluation of rotorcraft training simulators.

Products of This Research

The most important research to be initiated in FY 1989 will yield products ready for application early in the 1990s, including methods and procedures for evaluating human operators in automated systems, for certifying advanced technology airplanes and rotorcraft, and for identifying system characteristics that promote human error. Enhanced training requirements and training aids will be developed for flight crews and air traffic control specialists with emphasis on automated systems and other topical areas (e.g., cockpit resource management). Nearly all of the human factors research and development activities in FY 1989 are directed toward enhancing operator capabilities and minimizing the potential for operator error.

Future Research

Research areas that are anticipated for FY 1990 and beyond but remain to be funded include the development of standards and guidelines for the design and evaluation of automated systems, the determination of optimal levels of flight deck automation for normal and emergency operations, the investigation of error-resistant data-entry methods, the application of expert systems to air traffic control, the development and evaluation of new methods for the display and management of flight deck information, and the development of performance criteria for use in certifying flight deck man-machine interfaces.

14.1 Controller Human Factors

Responsible Division

ADS-100, Clyde Miller

Purpose

Integrate advanced ATC system functions from the operator perspective. Develop, analyze, and maintain a concept for evolving ATC systems to ensure that the intended human role is appropriate, effective, and properly supported.

Approach

The integrated ATC concept, which incorporates scenarios of individual automation developments contributing to system evolution, will be analyzed. A "road map" will show the various plateaus envisioned within each program. Each plateau, as well as the end-state concept, will be examined for functional overlaps and dependencies.

As software and hardware applications are examined, the appropriateness of the tasks assigned to them, as well as controller-machine interface considerations, will be studied. A standing group of operational and technical experts will analyze and influence system design to ensure operational acceptability and technical feasibility.

In addition, this project will define those areas where technology can reduce the likelihood of accidents caused by human error. From these analyses, research projects will be initiated to determine the operational and technical feasibility of introducing new technologies into the ATC system.

Products

- A concept of the evolution of the total ATC system based on planned scenarios with existing programs.
- A "road map" series of concepts based on the National Airspace System Facilities and Equipment Plan and RE&D Plan projects.
- New requirements to fully integrate the total ATC system.
- Reports on independent analysis and experimentation regarding human factor considerations.

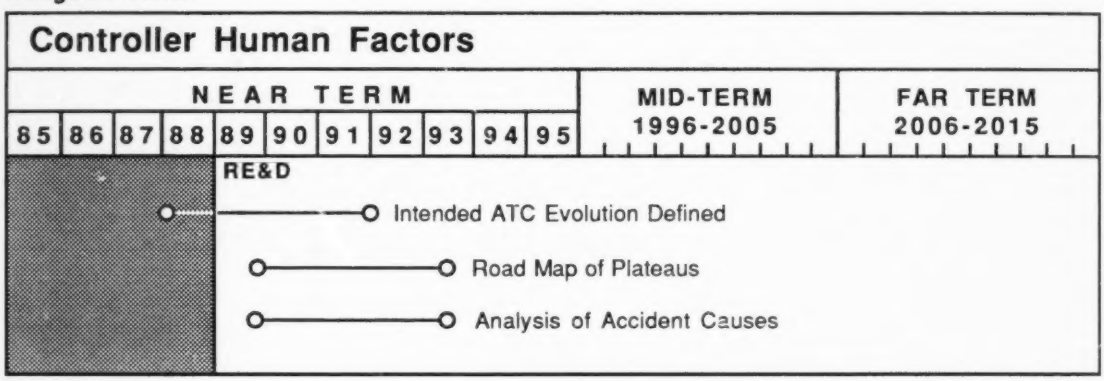
Recent Accomplishments

None - new start.

Related Projects/Activities

- Automated En Route Air Traffic Control 3 (AERA 3).
- Advanced Traffic Management System (ATMS).
- Terminal ATC Automation (TATCA).
- Airport Surface Traffic Automation (ASTA).

Project 14.1



14.2 AI Applications to Air Traffic Control

Responsible Division

ADS-100, Clyde Miller

Purpose

Explore and determine the technical and operational feasibility of applying artificial intelligence (AI) technology to the ATC process. AI includes expert systems, intelligent tutoring systems, voice recognition, and neural nets.

Approach

This project takes advantage of existing AI research and seeks ways of applying this body of research to specific ATC problems. There are currently four areas of applied AI research being explored: controller radar training automation, voice recognition, airspace and procedures design and evaluation, and neural net technology.

- Controller radar training automation -- This project builds on prior work conducted under the Small Business Innovation Research (SBIR) Program to investigate the feasibility of using expert systems to build an ATC trainer for terminal controllers.

  The current method for providing a trainee controller with a radar simulation control scenario requires an instructor controller plus at least one person to act as the pseudo pilot. Given the degree of human interaction required, there are inevitably training inconsistencies due to individual training styles, control techniques, and personalities of multiple instructors. The RE&D approach for this project is to explore advanced technology and training theories to determine the feasibility of computer-based instruction for supporting controller radar training.

  The project will identify controller training requirements that can be satisfied through the application of AI techniques. Prototype stand-alone hardware will be developed to demonstrate the feasibility of using advanced technologies to assist in the training of new controllers. Inherent in the design of these systems will be the use of state-of-the-art, intelligent man-machine interfaces.

- Voice recognition -- Research is being conducted on applications of voice recognition technology to control room communications activities. Voice recognition concepts will be developed that will make possible high levels of recognition accuracy with different controllers using standard vocabularies. Simulations will be conducted that will determine equipment standards and establish voice recognition parameters required for operation in the control room environments. Voice recognition equipment will be developed and integrated into control room procedures and data-link systems. Ways of improving radio voice quality will be studied, and the possibility of a radio link with automatic voice recognition will be explored.

- Airspace and procedures design and evaluation -- This project will establish a systems requirements team to determine the requirements for developing a tool that could be used by those designing airspace and procedures. These new designs can then be exercised under "what if" procedures to explore and analyze more efficient airspace design.
- Neural net technology -- Model neural nets have been developed with the ability to recognize the patterns inherent in temporal spatial processes, if these processes can be defined quantitatively. In theory, this means that if a neural net were connected to the ATC system, it could identify the control processes used by controllers and, in effect, "learn" how to control traffic. Innovative approaches are needed to explore the feasibility of applying neural net models to the ATC process and to assess the extent to which these techniques could be used. This project will initiate a look at neural nets through an SBIR Phase I effort.

Products

- Intelligent training system for ATC terminal controllers.
- Report on simulation evaluations of voice entry.
- Voice recognition equipment specification and guidelines.
- Prototype airspace and procedures design system.
- Report on the feasibility of neural nets in ATC.

Recent Accomplishments

Controller Radar Training Automation:

- Prototype demonstration.
- Completion of SBIR Phase I.
- Contract for SBIR Phase II.

Voice Recognition:

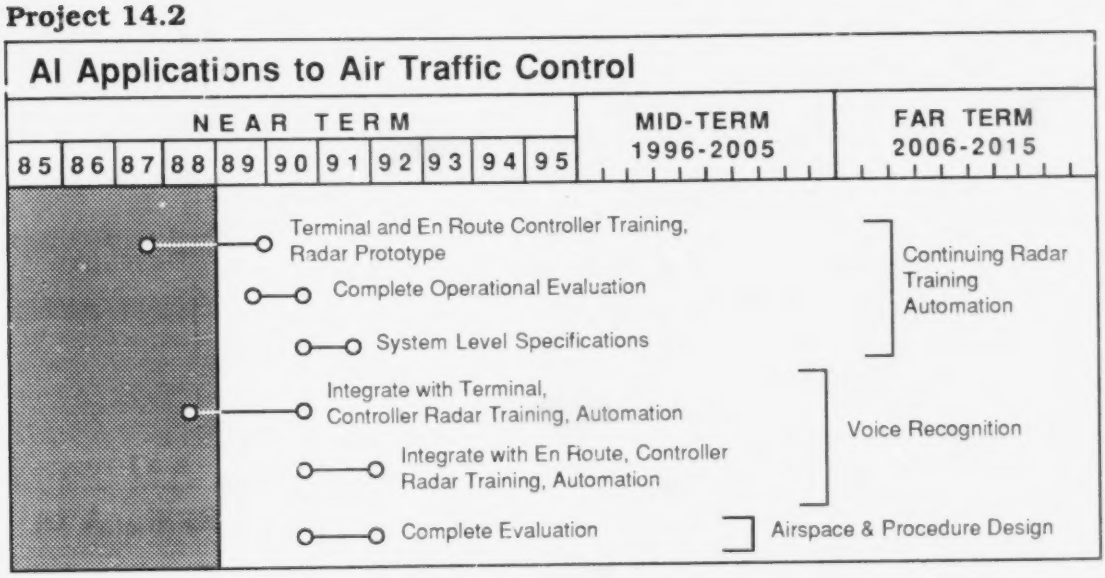
- Protype demonstration.
- Completion of SBIR Phase I.

Related Projects/Activities

- Automated En Route Air Traffic Control 3 (AERA 3) -- Will significantly automate the en route ATC process, including the aircraft separation function.
- Terminal ATC Automation (TATCA) -- Will develop ATC automation capabilities for the terminal environment.

- Advanced voice recognition systems -- The U.S. Air Force Flight Dynamics Laboratory is developing voice recognition systems that will recognize the pilot's verbal commands.
- Voice recognition systems -- Sikorsky Aircraft is evaluating voice recognition systems for rotorcraft that recognize a pilot's verbal commands.
- Advanced cockpit development -- Boeing is developing and evaluating voice recognition systems that will recognize pilots' verbal commands.

Project 14.2


AI Applications to Air Traffic Control
NEAR TERM
85 86 87 88 89 90 91 92 93 94 95
MID-TERM
1996-2005
FAR TERM
2006-2015
Terminal and En Route Controller Training, Radar Prototype
Complete Operational Evaluation
System Level Specifications
Continuing Radar Training Automation
Integrate with Terminal, Controller Radar Training, Automation
Integrate with En Route, Controller Radar Training, Automation
Voice Recognition
Complete Evaluation
Airspace & Procedure Design

14.3 Causal Factors in Accidents and Incidents

Responsible Division

ADS-200, William F. White

Purpose

Define human performance limits and capabilities for use in the design and certification of flight deck displays and controls, alerts and warnings, procedures, and training circulars. Evaluate the causes of human error on the flight deck.

Approach

Review the human factors literature and conduct laboratory and simulation studies to identify operational conditions that may reduce or enhance flight crew effectiveness. Analyze available accident and incident data and develop a classification scheme for pilot error. Problems to be addressed include fatigue, loss of situational awareness, reduced attention to systems monitoring, reductions in manual flight skills, task overload, and limits in information-processing ability.

Products

- Reports on the root causes of accidents and incidents with recommendations for flight crew training and operational procedures.
- Handbook of human operator characteristics to be considered in the design of cockpit procedures, displays, and control systems and in the determination of crew information requirements.
- Reports on the decision-making process in the cockpit and how to improve it.

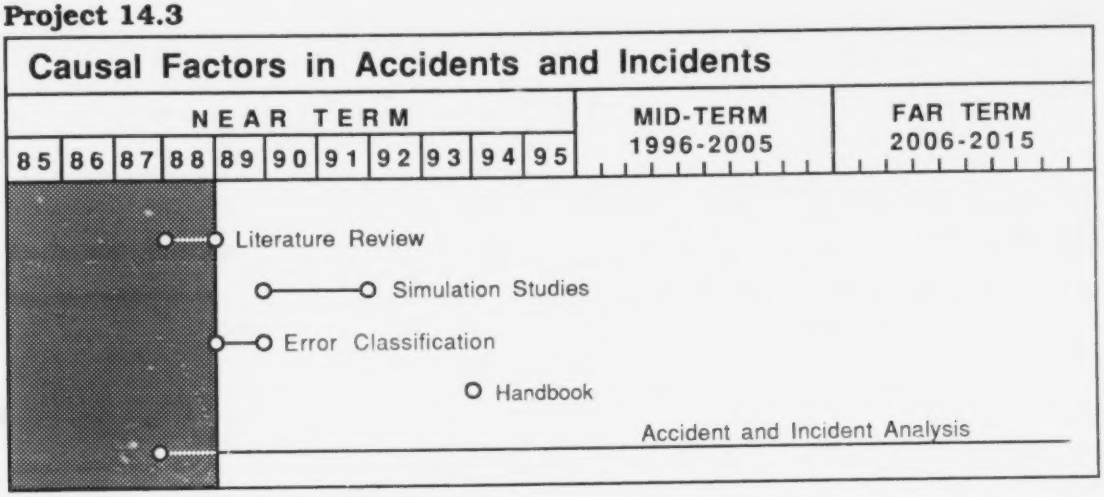
Recent Accomplishments

- Analysis of causes of terminal control area airspace violations.
- Initiated program with NASA and Boeing to analyze human factors databases, develop operator error models, and test error-reduction methods.

Related Projects/Activities

- Research on fatigue during long- and short-haul operations (NASA-Ames).
- Audit of in-flight errors (Boeing).
- Simulation studies on human factors issues related to the Traffic Alert and Collision Avoidance System (NASA-Ames).

Project 14.3


Causal Factors in Accidents and Incidents
NEAR TERM
85 86 87 88 89 90 91 92 93 94 95
MID-TERM
1996-2005
FAR TERM
2006-2015
Literature Review
Simulation Studies
Error Classification
Handbook
Accident and Incident Analysis

14.4 Human Performance Assessment and Improvement

Responsible Division

ADS-200, William F. White

Purpose

Develop techniques for studying and evaluating flight crew performance. Such techniques will support the development of new enhancement mechanisms.

Approach

The validity of selected workload measurement techniques will be established through flight simulations, and industry guidelines will be documented. The utility and applications of methods for collecting pilot performance data via simulators, flight data recorders, and video recorders are being investigated as means of studying flight crew performance and evaluating new concepts for enhancing capabilities. Empirical determinations of minimum visibility required to make safe Category III landings and the influence of head-up displays on these factors is being investigated. The influence of course deviation indicator (CDI) sensitivity on flight technical errors associated with area navigation systems is being investigated, and a study of operator programming errors with LORAN receivers is under way.

Products

- Updated FAA Advisory Circular 25.1523, "Minimum Flight Crew," based on a report on crew performance criteria.
- Recommended minimum set of behavioral measures for pilot performance assessment.
- Comparative evaluation of subjective and objective workload assessment techniques.

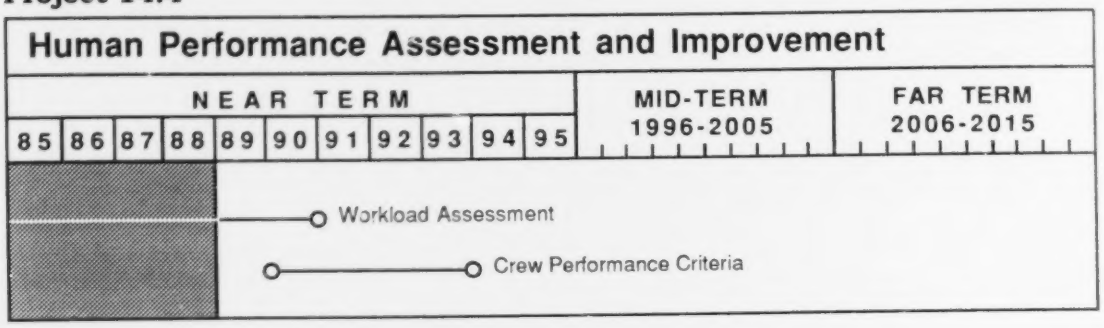
Recent Accomplishments

- Evaluation and validation of subjective and objective workload assessment techniques completed.
- Series of pilot judgment training manuals published.

Related Projects/Activities

- Society of Automotive Engineers (SAE) G-10 technical subcommittee on head-up displays.

Project 14.4


Human Performance Assessment and Improvement
NEAR TERM
85 86 87 88 89 90 91 92 93 94 95
MID-TERM
1996-2005
FAR TERM
2006-2015
Workload Assessment
Crew Performance Criteria

14.5 Information Transfer and Management

Responsible Division

ADS-200, William F. White

Purpose

Identify flight crew information requirements to develop operational and flight deck information management techniques.

Approach

Information from the air traffic system and the aircraft will be identified and classified to determine how data should be presented to, and managed by, the flight crew. This information will provide a basis for upgrading warning systems and displays. Flight crew and controller techniques for information transfer will be analyzed to help develop effective operations. System failures and their effects will be analyzed to identify potential problem areas, and recommended solutions will be developed.

Products

- Classification of flight deck information.
- Specification of flight deck information requirements.
- Survey of user requirements for data link.
- Report on the impact of data link on flight crew situational awareness.
- Recommended information transfer and management techniques.

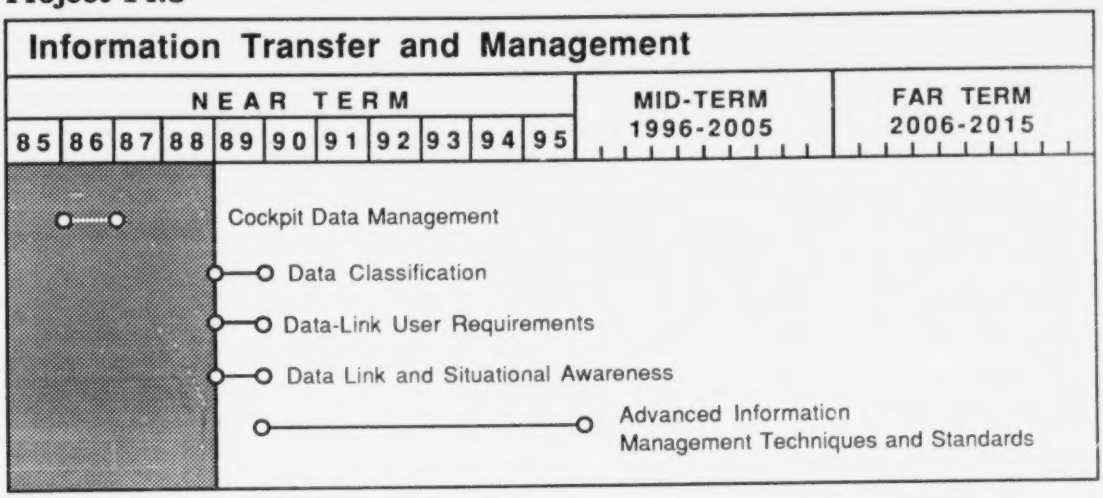
Recent Accomplishments

- Survey of flight crew weather information requirements.
- Flight data requirements for typical wide-body aircraft defined.
- Timeline analysis of data link and Traffic Alert and Collision Avoidance System (TCAS) flight crew tasking.

Related Projects/Activities

- Terminal area information system research at NASA Ames.
- Data-link applications.
- Traffic Alert and Collision Avoidance System (TCAS).

Project 14.5


Information Transfer and Management
NEAR TERM
85 86 87 88 89 90 91 92 93 94 95
MID-TERM
1996-2005
FAR TERM
2006-2015
Cockpit Data Management
Data Classification
Data-Link User Requirements
Data Link and Situational Awareness
Advanced Information
Management Techniques and Standards

14.6 Aircraft Automation

Responsible Division

ADS-200, William F. White

Purpose

Ensure that flight deck automation supports flight crews' abilities to operate advanced technology aircraft safely in both nonautomated and automated flight. Ensure that the evolving national aviation system and advanced technology cockpits are compatible.

Approach

Surveys of flight crews will help identify operational errors and other problems concerning advanced technology flight decks. Operating experience with existing aircraft systems and other automated systems will be analyzed to define failure modes and human capability to detect and recover from these failures. Design characteristics and operational procedures that may induce pilot error will be identified and addressed. Intra-agency design review requirements and evaluation methods will be developed to ensure that the modernization of the national aviation system and related changes in the cockpit can be safely managed.

Products

- Reports on flight crew workload distribution and performance for differing mixes of manual and automated flight deck functions.
- Documentation of lessons learned from existing automated systems.
- Intra-agency review and evaluation procedures.
- Advisory circular on operational procedures for advanced technology aircraft.

Recent Accomplishments

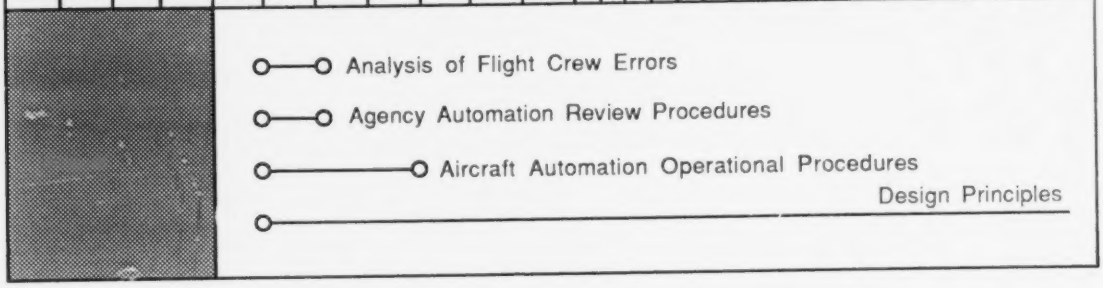
- Initiated program with NASA to investigate improved human interfaces to automated systems.
- Support and participation in NASA workshop on flight deck automation.
- Conducted flight simulator evaluation of expert systems application to flight-phase status monitor.

Related Projects/Activities

- NASA aviation safety and automation program.

Project 14.6

Aircraft Automation



14.7 Control and Display Technology

Responsible Division

ADS-200, William F. White

Purpose

Develop procedures and guidelines, based on crew performance, for the use of displays and controls in advanced technology cockpits. Technologies to be considered include data link, electronic charting, and data-input devices.

Approach

Laboratory studies, simulations, and field tests will be conducted to develop human factors criteria for evaluating cockpit displays and controls. Guidelines will be developed for the employment of electronically generated charts. Various input and output options for interfacing with data link will be evaluated.

Products

- Criteria for the design of instrument procedures charts and displays.
- Recommendations for data-link display options and applications.
- Functional requirements for data-input devices.
- Recommendations for the design and evaluation of displays and controls.

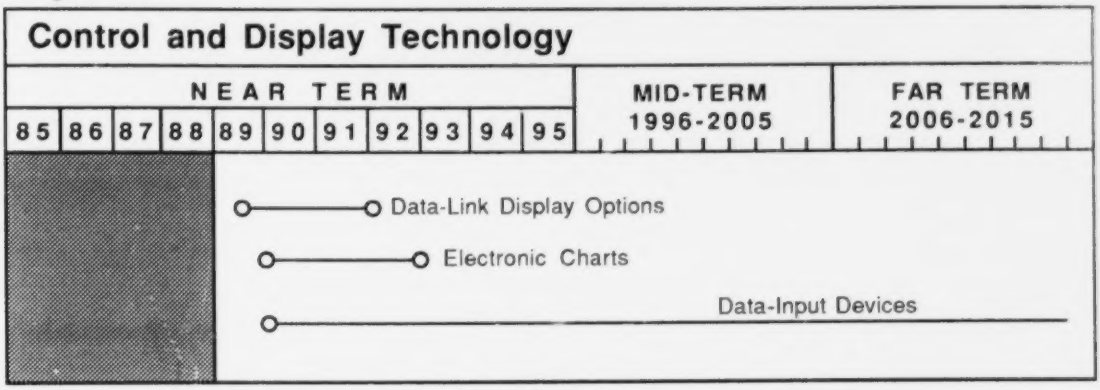
Recent Accomplishments

- Report on use of color displays for airborne applications.
- Lab tests of controls and displays for flight-phase status monitor.
- Survey of pilots on advantages and disadvantages of current instrument approach chart design (aviation systems concepts).
- Report on filtering, alerting, and display requirements for lookahead airborne windshear detection systems.

Related Projects/Activities

- Analysis of current ATC radiotelephone communications and related data-link applications (MITRE).
- SAE G-10 subcommittee formed to examine instrument approach charts.

Project 14.7


Control and Display Technology
NEAR TERM
85 86 87 88 89 90 91 92 93 94 95
MID-TERM
1996-2005
FAR TERM
2006-2015
Data-Link Display Options
Electronic Charts
Data-Input Devices

14.8 ATC Weather Information Transfer

Responsible Division

ADS-200, William F. White

Purpose

Develop standards for flight deck weather information management systems.

Approach

Weather information needs will be defined for aircrew planning and decision making. Alternative weather information system configurations will be developed and evaluated for the integration of ground-based and airborne weather data. Analyses will also be conducted of weather information transfer incident reports in the airport surface radar surveillance/aviation safety reporting system database.

Products

- Flight deck weather information and display requirements.

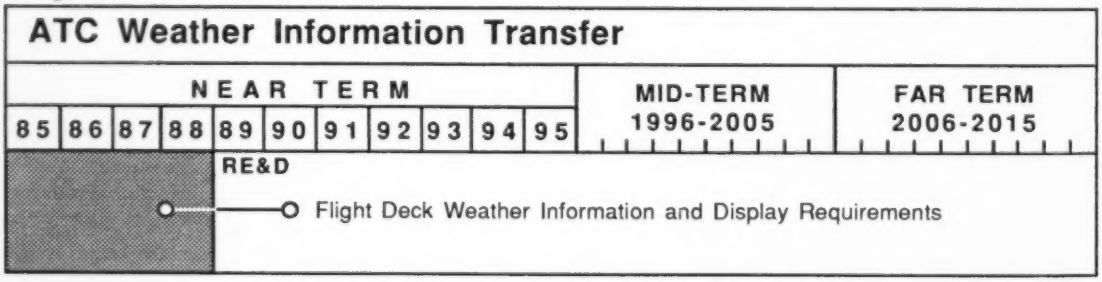
Recent Accomplishments

- Completed study of requirements for flight deck display of terminal radar information.
- Completed search of weather incident data.

Related Projects/Activities

- Airborne Windshear Detection and Avoidance.
- Information Transfer and Management.

Project 14.8



14.9 Interactive Voice Systems

Responsible Division

ADS-200, William F. White

Purpose

Develop guidelines for the use of interactive voice systems in rotorcraft cockpits and performance criteria for the certification of such systems.

Approach

Similar efforts by the Department of Defense, NASA, and industry will be reviewed and monitored. Cockpit applications of voice activation will be identified, and research will be performed on the effectiveness of interactive voice systems in high-workload situations. Simulations will be conducted in operational environments, and flight tests performed.

Products

- Report on simulation design.
- Report on flight test evaluation.
- Guidelines for voice-activated controls.
- Draft advisory circular on voice-activated cockpit instruments.

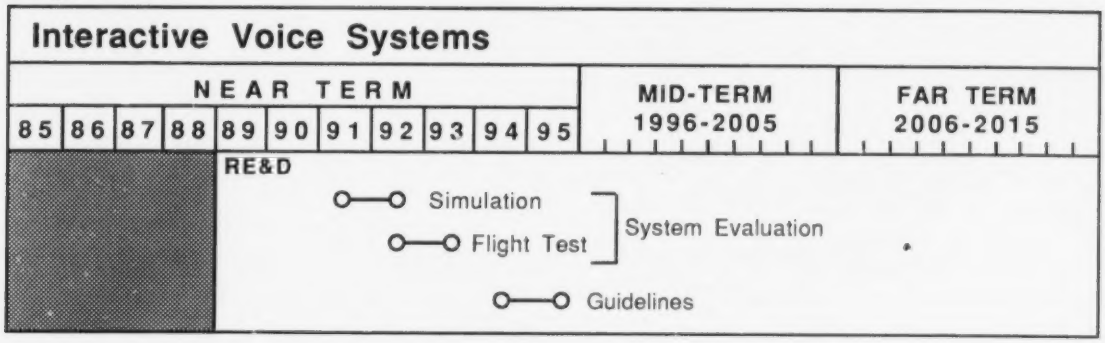
Recent Accomplishments

None - new start.

Related Projects/Activities

- Advanced voice recognition systems -- The U.S. Air Force Flight Dynamics Laboratory is developing voice recognition systems that will recognize a pilot's verbal commands.
- Advanced cockpit development -- Boeing is developing and evaluating voice recognition systems that will recognize a pilot's verbal commands.
- General aviation applications -- NASA-Langley is developing voice recognition systems for general aviation that will recognize pilots' verbal commands.

Project 14.9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MID-TERM
1996-2005
FAR TERM
2006-2015
RE&D
Simulation
Flight Test
System Evaluation
Guidelines

14.10 Flight Deck Certification Criteria

Responsible Division

ADS-200, William F. White

Purpose

Utilize the results of man-machine interface research to develop criteria for the certification of advanced technology cockpit displays, flight deck procedures, and control systems.

Approach

Criteria will be developed for high and low limits for the mental and physical effort required by flight crews to operate advanced flight deck systems. Certification criteria will also be produced for new flight deck designs and retrofits to existing flight decks. Methodology for evaluating the likelihood of design-induced operator errors will be developed.

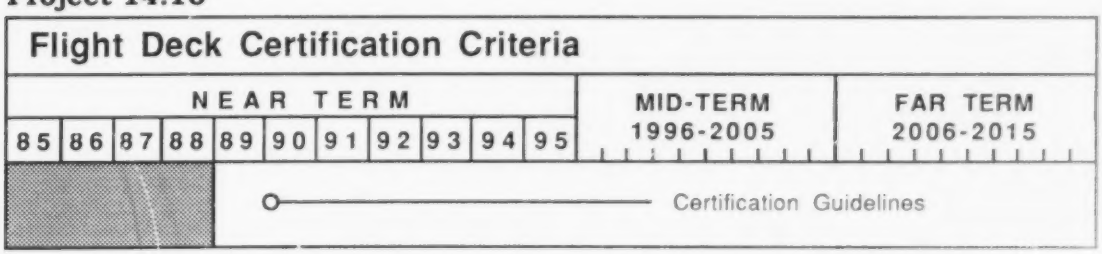
Products

- Evaluation criteria for displays and data-input devices.
- Guidelines for certifying flight deck automation.

Recent Accomplishments

FY 1990 new start.

Project 14.10



14.11 Flight Crew Certification and Training

Responsible Division

ADS-200, William F. White

Purpose

Upgrade flight crew training programs in advanced technology aircraft. Criteria developed will address cockpit and cabin resource management and flight crew simulator training. The program will ensure that pilot selection and certification criteria satisfy the operational requirements of the increasingly automated flight environment.

Approach

Review Parts 121 and 135 training regulations. Survey practices and training in cockpit and cabin crew coordination and management of crew resources. Determine the extent to which inexpensive simulators and part-task trainers can be used at all levels of pilot training. Evaluate how advanced simulators can be improved to train pilots more efficiently and to identify weaknesses in company training programs. Analyze flight crew tasks to identify the knowledge, skills, and abilities flight crew members need to satisfy their responsibilities.

Products

- Recommendations for revisions to Parts 121 and 135 training regulations.
- Advisory circular for design and implementation of cockpit resource management (CRM) programs.
- Report of an analysis of Parts 91, 135, and 121 training requirements and recommended use of minimum fidelity simulators and training devices required to satisfy them.
- Lists and descriptions of flight crew tasks and the knowledge, skill, and abilities required to accomplish each one.

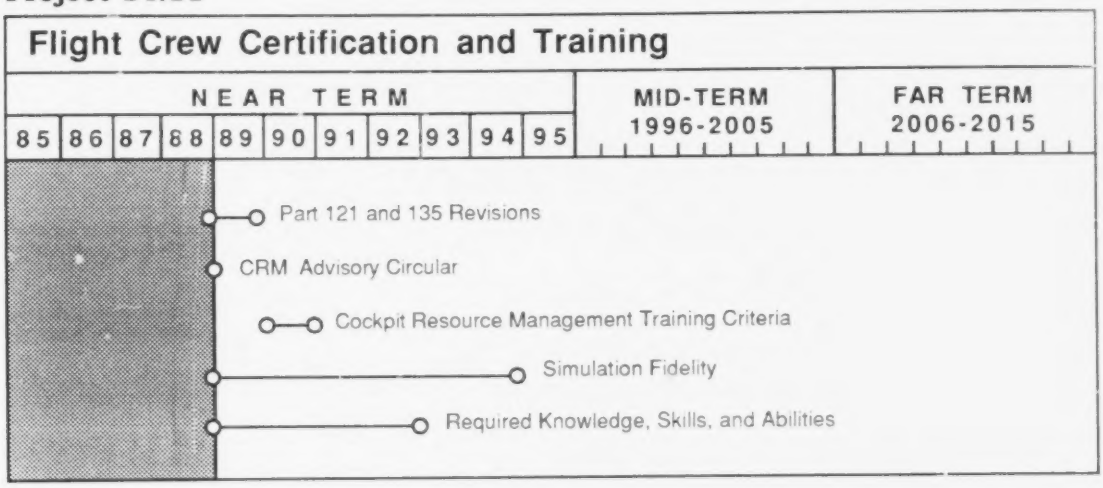
Recent Accomplishments

- Advisory circular on cockpit resource management training completed.
- Review of Parts 135 and 121 training requirements by government/industry working group on crew performance completed.
- Job task analysis of flight crew tasks initiated.
- Methodology for determining fidelity requirements for training simulators developed.

Related Projects/Activities

- MIT/NASA research on minimum motion requirements for training simulators.
- FAA evaluation of CRM training at United Airlines.

Project 14.11



14.12 Human Factors and Regulatory Support

Responsible Division

ADS-200, William F. White

Purpose

Define and perform human factors support of ongoing FAA RE&D programs. Prepare and maintain an updated human factors plan and disseminate program information to the aviation community.

Approach

Maintain cognizance of the nature and status of FAA research activities; review the procedures, approach, and anticipated products with users and coordinate efforts with those of other groups within the aviation community. Biennial symposia will be conducted to report the status of aviation safety and human factors research, identify flight deck problems requiring attention, and provide a means of coordinating revisions of the FAA Cockpit Human Factors Plan with aviation users.

Some larger projects currently under way include the analysis of flight simulator data during low-visibility operations to support regulatory actions on weather minima and flight crew training, and a human factors evaluation of LORAN C equipment, approach procedure, and chart design.

Products

- FAA Cockpit Human Factors Research Plan, with periodic updates.
- Human factors research symposia and published proceedings.
- Procedures and minima for CAT III landings.
- Recommended CDI sensitivity levels for area navigation systems.
- Report on the influence of area navigation display and control design on operator errors and training requirements.

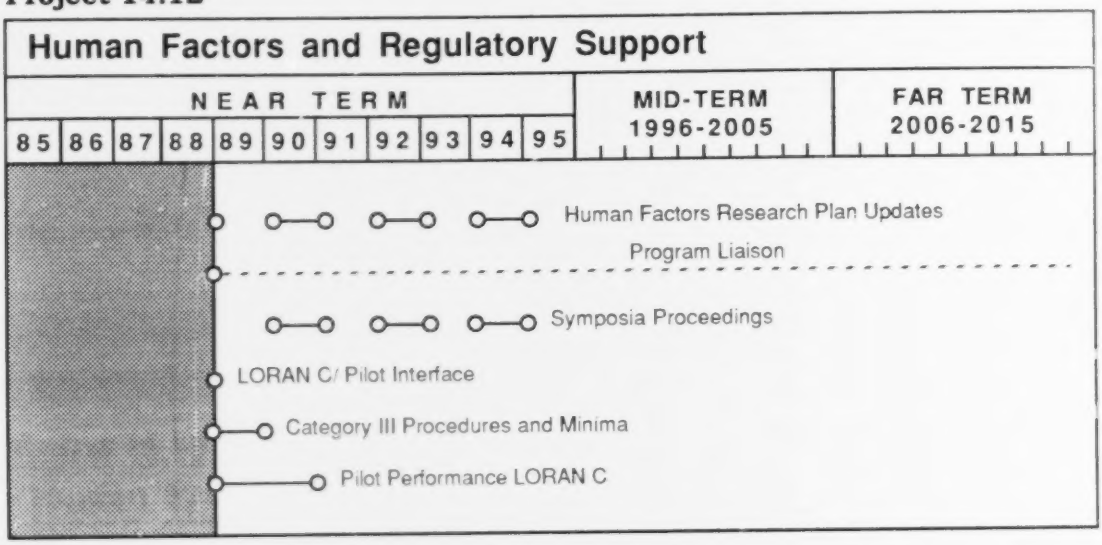
Recent Accomplishments

- Updated research requirements for the FAA Human Factors Research Plan.
- Completed data analysis of pilot performance on Category II approaches.
- Initiated study of LORAN C-CDI sensitivity on approach-path precision.
- Initiated laboratory study of pilot errors in LORAN C programming.

Related Projects/Activities

- Air Transport Association Human Factors Priority Work Program.
- The Ohio State University biennial Symposium on Aviation Psychology.

Project 14.12


Human Factors and Regulatory Support
NEAR TERM
MID-TERM 1996-2005
FAR TERM 2006-2015
85 86 87 88 89 90 91 92 93 94 95
Human Factors Research Plan Updates
Program Liaison
Symposia Proceedings
LORAN C/ Pilot Interface
Category III Procedures and Minima
Pilot Performance LORAN C

Appendix A

RE&D Project Index

A consolidated list of all RE&D projects described in this plan is contained in Table A-I in numerical order by chapter. Table A-II contains an alphabetical list of all RE&D projects.

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Appendix B

Glossary of Acronyms and Abbreviations

A

AAS	advanced automation system
AATMS	advanced air traffic management system
ACF	area control facility
ADS	automatic dependent surveillance
ADSIM	airfield delay simulation model
ADIZ	air defense identification zone
ADM	Advanced Design and Management Control
AEEC	Airlines Electronic Engineering Committee
AERA	automated en route ATC
AFSS	automated flight service station
AI	artificial intelligence
AIAA	American Institute of Aeronautics and Astronautics
ALSIP	Approach Lighting System Improvement Plan
AM	amplitude modulation
AMPS	ATCRBS monopulse processing system
ARSR	air route surveillance radar
ARTCC	air route traffic control center
ARTS	automated radar terminal system
ASD	aircraft situation display
ASDE	airport surface detection equipment
ASOS	automated surface observing system
ASR	airport surveillance radar
ASRS	airport surface radar surveillance/aviation safety reporting system
ASTA	airport surface traffic automation

ATA	airport traffic area
ATACT	Air Traffic AERA Concepts Team
ATC	air traffic control
ATCAC	Air Traffic Control Advisory Committee
ATCBI	air traffic control beacon interrogator
ATCF	air traffic control facility
ATCRBS	air traffic control radar beacon system
ATCS	air traffic control specialist
ATCT	air traffic control tower
AT&T	American Telephone and Telegraph
ATIS	automated terminal information service
ATMS	advanced traffic management system
AWOS	automated weather observing system
AWP	aviation weather processor
AXD	Executive Director for System Development

B

BCAS	beacon collision avoidance system

C

CAMI	Civil Aeromedical Institute
CAS	collision avoidance system
CAT	category
CCD	configuration control decision
CDI	course deviation indicator
CDT	controlled departure time
CEP	Central East Pacific

CFCF	central flow control function
CFWSU	central flow weather service unit
C/N/S	communications, navigation, and surveillance
CONUS	contiguous or conterminous United States
CRM	cockpit resource management
CWP	central weather processor
CWSU	central weather service unit

D

DF	direction finder
DFM	departure flow management
DME	distance measuring equipment
DME/P	precision distance measuring equipment
DoD	U.S. Department of Defense
DOT	U.S. Department of Transportation
DOTS	dynamic ocean track system

E

EMI	electromagnetic interference
EPA	Environmental Protection Agency
ERM	en route metering
ETMS	enhanced traffic management system

F

FAA	Federal Aviation Administration
FANS	Future Air Navigation Systems

F&E	facilities and equipment
FIR	flight information region
FMS	flight management system
FRP	Federal Radionavigation Plan
FSAS	flight service automation system
FSDPS	flight service data processing system
FSS	flight service station

G

GA	general aviation
GAO	General Accounting Office
GIC	GPS integrity channel
GPS	global positioning system

H

HERF	high-energy radio frequency field
HF	high frequency
HST	hypersonic transport

I

ICAO	International Civil Aviation Organization
ICS	independent cooperative surveillance
ICSS	integrated communication switching system
IFCN	interfacility flow control network
IFR	instrument flight rules
ILS	instrument landing system

IMC	instrument meteorological conditions

J

JSPO	Joint System Program Office

L

LIDAR	light detection and ranging
LIP	limited installation program
LLWAS	low-level windshear alert system
LOFF	LORAN C flight following
LOFT	line-oriented flight training
LORAN	long-range navigation

M

MALSR	medium-intensity approach lighting system with runway alignment indicator lights
MCCs	maintenance control centers
MIS	management information system
MIST	microburst and severe thunderstorm
MIT	Massachusetts Institute of Technology
MLS	microwave landing system
MNPS	minimum navigation performance standards
Mode S	discrete addressable secondary radar system with data link
MOPS	minimum operational performance standards
MPS	maintenance processor subsystem
MRU	military radar unit

MSN	message-switching network
MWP	meteorologist weather processor

N

NADIN	national airspace data interchange network
NASA	National Aeronautics and Space Administration
NASPAC	national airspace system performance analysis capability
NAS	National Airspace System
NAT	North Atlantic
NATSPG	North Atlantic special planning group
NDB	nondirectional beacon
NDI	nondestructive inspection
NDT	nondestructive testing
NEXRAD	next generation weather radar
NICS	NAS interfacility communications system
NMC	National Meteorological Center
NMCE	network management and control equipment
NOPAC	North Pacific
NOAA	National Oceanic and Atmospheric Administration
NOSAM	national oil shortage analysis model
NOTAM	notice to airmen
NPIAS	National Plan of Integrated Airport Systems
NPRM	notice of proposed rulemaking
NRC	National Research Council
NSF	National Science Foundation
NTSB	National Transportation Safety Board
NWS	National Weather Service

O

OAM	Office of Aviation Medicine
ODAPS	oceanic display and planning system
OFCM	Office of Federal Coordinator for Meteorological Services and Supporting Research
OMB	Office of Management and Budget
OMEGA	very low frequency, phase comparison radionavigation system operated by the United States and a consortia of other countries
OSI	open systems interconnection
OST	Office of the Secretary of Transportation
OSTP	Office of Science and Technology Policy
OTA	Office of Technology Assessment

P

PIREP	pilot report
PMS	performance management system
PSN	NADIN packet-switching network

R

RCE	radio control equipment
RCL	radio communications link
RCMS	runway configuration management system
RDSIM	runway delay simulation model
RE&D Plan	Research, Engineering, and Development Plan
RF	radio frequency
RFF	rescue and firefighting

RGCSP	review of the general concepts of separation panel
RML	radar microwave link
RMMS	remote maintenance monitoring system
RNAV	area navigation
RNPC	required navigation performance capability
ROT	runway occupancy time
RTCA	Radio Technical Commission for Aeronautics
RVR	runway visual range
RWP	real-time weather processor

S

SAE	Society of Automotive Engineers
SBIR	Small Business Innovation Research
SC	special committee
SIMMOD	simulation model development and validation
SRT	systems requirements team
SSR	secondary surveillance radar
SST	supersonic transport
STEP	Service Test and Evaluation Program
STOL	short takeoff and landing
STORM	stormscale operational and research meteorology
SUA	special-use airspace

T

TACAN	tactical aircraft control and navigation
TATCA	terminal ATC automation
TCA	terminal control area

TCAS	traffic alert and collision avoidance system
TCS	tower communications system
TDWR	terminal Doppler weather radar
TERPS	terminal instrument procedures
TMS	traffic management system
TMU	traffic management unit
TNA	thermal neutron activation
TRACAB	terminal radar approach control in the tower cab
TRACON	terminal radar approach control facility
TRB	Transportation Research Board

U

UHF	ultra-high frequency
UPT	user-preferred trajectory
USAF	U.S. Air Force

V

VFR	visual flight rules
VHF	very high frequency
VIEWS	visual imaging electromagnetic window system
VMC	visual meteorological conditions
VOR	VHF omnidirectional range
VORTAC	VHF omnidirectional range/TACAN
VSCS	voice switching and control system
VTOL	vertical takeoff and landing

W

WAT	West Atlantic
WCP	weather communications processor
WMSCR	weather message switching center replacement

#

2D	2-dimensional
3D	3-dimensional
4D	4-dimensional